NDBOOK of PROJECTION

for

ater Managers and Projectionists

Fourth Edition

by

F·H·RICHARDSON

A Chalmers Publication

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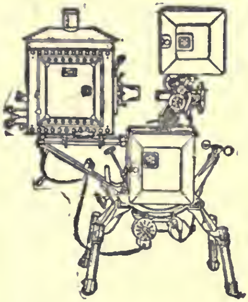

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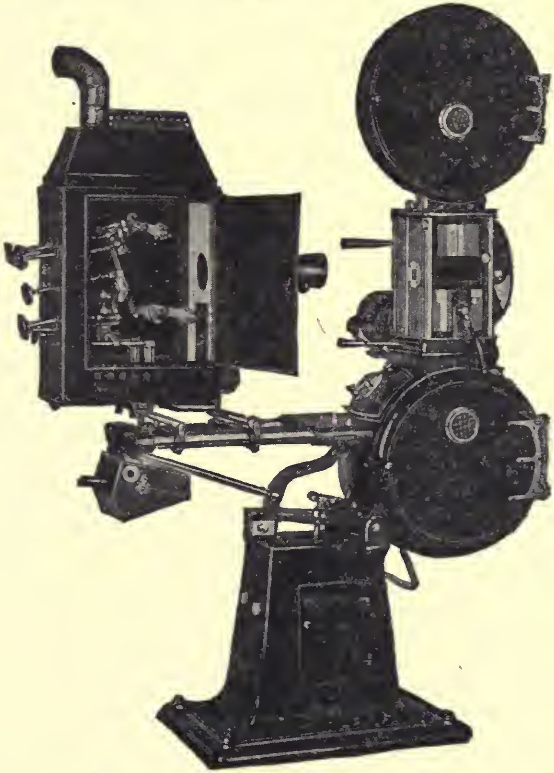

Rich.

Frank Herbert

RICHARDSON'S

HANDBOOK
OF
PROJECTION

FOR THEATRE MANAGERS AND MOTION PICTURE PROJECTIONISTS

FOURTH EDITION

PUBLISHED BY
CHALMERS PUBLISHING COMPANY
516 FIFTH AVENUE
NEW YORK CITY

To the memory of my friend
James P. Chalmers
I dedicate this work, it being
the first of my books I have
believed to be worthy of so
signal an honor

J. H. Richardson

Author's Note

I HAVE striven hard to make this, the fourth edition of my handbook of projection, worthy of the sincere commendation of those who will consult its pages. It is not perfect—true, but few things in this world are perfect, and I have faith to believe those who use the book will look with kindly eyes upon its shortcomings, remembering that the work was a large one, and that much of the ground had to be broken as virgin sod.

I want to embrace this opportunity to tender my sincere thanks to those thousands of users of former editions of the handbook who have said such kindly things concerning them. Their words of commendation have given me courage to complete the compilation of this, the fourth edition, at times when the burden of the work seemed unbearably heavy.

Publisher's Word

IN October, 1910, this company brought out the first edition of the Handbook of Projection, by F. H. Richardson. Since that time three separate editions, each bigger and better than the other, have been published and sold. It is with pardonable pride that we now offer to the motion picture industry this new edition which is the largest, most complete, and accurate treatise on projection ever written. We firmly believe the motion picture industry will find that this, the fourth edition, far surpasses its predecessors in scope and arrangement of contents. In the constant endeavor for finer and healthier entertainment on the screen, projection has played a most important role. We therefore offer this latest work by Mr. Richardson in the field of projection with the sincere belief that all who read it will be helped and a great industry thereby benefited.

CHALMERS PUBLISHING COMPANY.

Index

TO make a really satisfactory index for a work of this kind presents a most difficult problem. I have found a strictly alphabetical index to be far from satisfying, and have therefore adopted a new plan in this edition, which, I hope and believe, will serve very well. If you want something concerning the screen, look under the heading of "Screen." If it is something about a projector, look under projectors, and so on. The plan is not perfect, but, I believe, it is much better than a straight alphabetical arrangement.

THE AUTHOR.

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NOTE: *It was found too late for correction in the text that the correct name is "white" cement, instead of "neat" cement.*

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MANAGERS AND PROJECTIONISTS

Important Foreword

MODERN projection covers such a huge field that to treat it and all things allied to it in exhaustive detail would require a book of very much more than a thousand pages. Such a volume, besides being expensive in price, would be unwieldy, easily injured and in every way awkward. Dividing the work into two or more volumes has very serious objections, hence, in what we believe to be the best interests of all concerned, the following plan has been adopted for keeping both size and price within reasonable limits.

In dealing with both electrics and optics there are many things which need not necessarily be understood in large detail by the projectionist, and which comparatively few would study, even though they be set forth in detail in this book. In such matters we have decided to give the essential facts as briefly as may be and refer our readers to other readily available standard text books for details.

We will, however, so far as possible, confine such references to books which the projectionist is likely to already own, or which he may consult in almost any public library. We believe our readers will heartily approve this plan, because, while causing no hardship, it will reduce the handbook both in bulk and price.

The "Hawkins' Electrical Guides," by Hawkins, and "Optic Projection," by the Professors Gage, will be used for reference wherever possible, because these most excellent works are already in the library of many projectionists and should be owned by them all.

Quite a little of what may seem repetition will be found in this book. This is because it is found necessary to mention certain things in several different connections, and to do so by cross reference would not always serve the best purpose. There is no duplication except in cases where the author believed duplication would serve the best interests of the users of the book.

THE AUTHOR.

Projection in the Modern Moving Picture Theatre and What It Entails

MODERN motion picture theatres are indeed temples of beauty. In many cases they represent an outlay reaching well into six figures, the income from which depends very largely upon the excellence of what paying patrons see upon the screen. Great producing companies have established reputations which have drawing power at the box office. The same is true of what we term "stars." The expert work of cameramen, and those others who contribute to the truly wonderful photographic results found in modern films, all have their share in popularizing the motion picture as a salable form of theatrical amusement. A good orchestra has considerable drawing power.

Fine seats, good ventilation, beautiful light effects and decorations all lend aid in the sale of tickets, but the fact remains that even though a theatre have all these things, **still, if there be anything less than high class, expert work in the projection room, the shadow forms of the artists will not appear to best advantage, the photography, though wonderfully beautiful in the film itself, will be only ordinary on the screen, and in many other ways the show will be made less pleasing, with the result that the box office income will inevitably suffer.**

The following is put forward as a flat statement of amply proven fact: Given a free hand, unhampered by unreasonable schedule restrictions, limited amperage or penuriousness in the matter of projection room operating expense, the careful, painstaking projectionist who is equipped with expert knowledge of his profession, can "put over" a production of mediocre merit, sending forth an audience at least fairly well pleased and of mind to come again; whereas the slovenly, careless projectionist, or the projectionist not equipped with expert knowledge, although otherwise equally unhampered, will either cause the same subject to fall flat, or will give a less satisfactory performance with a production of far superior merit; and since inferior screen results must inevitably react unfavorably on future ticket sales, it follows that **careful work and expert projection knowledge has direct value to the box office through increased patronage of the theatre.**

Not only is this true, but the well informed projectionist is in a position to effect material saving in projection room expenditures, both in the matter of daily operating expense and in better and longer service of equipment. This latter item may be a very large one indeed, if we include the possible saving in film damage through intelligent adjustment of the machine tensions and intelligence in the matter of rewinding and handling of film, remembering that **all film damage must, in the last analysis, be charged back to the theatre in the form of increased film rentals made necessary by added overhead expense to exchanges through frequent purchase of prints to replace those ruined by unintelligent handling.**

With these facts in view we may readily understand the importance attached to the study of the details of his profession by the projectionist, and this book is designed primarily to supply detailed information, in plain words and understandable form, concerning those many things the competent, modern projectionist should and must know.

We shall labor hard to produce the best book possible, but have no hope of attaining perfection. The work is a large one and it is inevitable that some errors—minor ones only, we trust—will be found in its text. These we ask you to view with charity, remembering that few things in this world of ours are perfect.

PRACTICAL THINGS OF GREATEST IMPORTANCE.— This book, like its predecessors, is designed for the use of practical men, hence, as in past editions, we shall pay very much more attention to practical things and understandableness, than to absolute technical correctness. Strict technical correctness, especially in matters electrical and optical, often involves the use of a maze of words and technical terms, many of which latter could not possibly be understood by the ordinary man without such long-winded explanations that the novice would become confused and discouraged.

Therefore, when we are able to make a point sufficiently clear for all practical purposes merely by the sacrifice of some unimportant point of technical correctness, we shall unhesitatingly do so, believing that course to be, all things considered, best.

Electrical Action

IN order to arrive at a comprehensive knowledge of electricity, one must first understand the underlying principles which govern its action. It is absolutely imperative that the projectionist have at least a good working knowledge of electrical action, because he will be put in full charge of apparatus for generating and using current, which devices will operate safely and with high efficiency, or with low efficiency and perhaps unsafely, exactly in proportion to the expert skill and knowledge he is able to make use of in their adjustment, care and handling.

We will first try to convey an understanding of the one basic, underlying principle upon which all electrical action is based, always remembering that electricity and magnetism are two entirely separate and distinct things, notwithstanding statements of some authorities to the contrary.

POLARITY.—Polarity is the very foundation principle upon which all electrical action is based. Precisely what electricity is, no living man knows. Eminent scientists differ widely in their views as to the cause of the phenomenon. Some authorities claim it to be a "molecular bombardment," while others hold it to be something entirely different. With such arguments the practical man has little interest. At best they represent little more than abstract theories. They have no importance as applied to the work of projection.

We may not know the precise nature of the thing which does it, but we do know that if we touch a "live" positive wire to a negative wire attached to the same generator, there will be a flash and a shower of sparks. We also know that by connecting these two wires through certain devices, such as motors and lamps, instead of an uncontrolled flash and shower of sparks we can and do get light, heat or power. In other words we can make the electric force work for us in its passage from positive to negative.

So far as electric action is concerned, every electric circuit consists of just two wires—a positive and a negative. True, there may appear to be more, as in the three-wire system, but when analyzed we find that the additional wire or wires merely operate to form additional complete circuits, which may either be used singly or together, as will be fully explained in the proper place.

One positive and one negative conductor constitutes what is called a "circuit." Every electric generator (dynamo) and every battery has a "positive" and a "negative" pole. In order that the power of the generator or battery be available for use at a distance, we attach a wire to each of these poles. These wires become a part of and represent the poles of the generator or battery, so that connecting a lamp or motor to them at any portion of their length is the same as attaching it to the actual poles of the machine itself, modified only by the fact that resistance is offered by the wires to electric action which for a given size of wire increases as the length of the wire increases, as will be fully explained under the proper heading.

When disconnected from the generator, or when the generator is not running, these wires are precisely the same as any ordinary wire. They are "dead." But the instant they are connected to the poles of a working generator or battery they become "live wires," the positive wire becoming charged with an electrical energy which, measured in "volts," is called "voltage" and corresponds to pressure in a steam boiler. Steam confined under pressure in a boiler seeks to expand its volume, since by so doing its pressure is reduced. When it escapes into the open air its pressure is reduced to atmospheric pressure, hence it seeks always to so escape.

Electricity under pressure, or tension, in the positive wire seeks to escape into the negative wire for precisely the same reason—its pressure or tension is reduced to zero by so doing.

Technical electricians will no doubt feel inclined to criticise our last statement, but while they may do so from the purely technical standpoint, what we have said describes what actually apparently takes place in practice, and **it is understandable.** Those who care to go into fine-spun theories will find books in plenty which will carry them as far as they may wish to go into a very maze of it, but when they have done, they will only be able to tell us, in technical language, what for all practical purposes amounts to precisely what we have just said. Our concern is to make you understand the **practical** effect of what takes place between positive and negative. If we accomplish that result we are well satisfied.

The affinity of positive for negative—the desire, if you please, of the positive energy to become negative—is what we term "polarity." It represents difference in electrical pressure as between positive (+) and negative (—). It is measured in volts.

HOW WORK IS PERFORMED.—Steam under pressure generated by confining it in a boiler, seeks to lower its pressure by expanding in volume. We allow it to enter the cylinder of a steam engine in which is a movable piston. On one side of the piston is the pressure of the steam, and on the other only the pressure of the air, which for our purpose represents zero. In seeking to expand its volume, and thus reduce its pressure, the steam will shove the piston ahead of it to the end of the cylinder, pulling with it the load attached to it, thus generating power.

In doing this the steam itself is not consumed. It still exists, having been discharged into the open air, but its pressure has been consumed. Steam is merely the medium, the compression of which stores up power. It acts precisely as does a coil spring. Compress the spring and you will have stored-up power, which will be available until the spring has again expanded to its former state, whereupon, while the spring itself remains, the power has all been expended and is gone.

We cannot see electricity. The light we see in a lamp is not electricity itself, but a product of its power. We cannot weigh it. Apparently it has no weight. We cannot feel it, except in the form of a "shock," which again is not electricity itself but a product of its power. We do, however, find its action to be almost precisely the same as that of steam or water under pressure, so that we may readily use these as a basis for comparison.

Apparently, as already set forth, electricity exists under pressure on one wire, the positive, and apparently it loses its pressure in the act of entering the negative wire—the act of becoming negative—hence, since pressure is power and pressure is consumed in passing from positive to negative, it follows that power is generated when current passes from positive to negative and this power is made available for use by means of what amounts to an electric engine, one side (pole) of which is connected to positive and the other to negative. The particular power generating device may be a lamp, by means of which light is produced, a motor by means of which pulling power is made available, or it may be a heating coil. In either case electricity is made to do a useful thing, hence its power is turned into useful channels.

THE EARTH AND THE POWER SOURCE.—There is a mistaken idea entertained by many, that electricity seeks to escape from the wires into the earth. This is not true, except insofar as the earth offers a path for the current from positive to negative. Let it be clearly understood that:

There is absolutely no electrical affinity of the positive wire of a battery or dynamo for anything else except a wire attached to the negative pole of the same battery or generator, except in cases where two or more batteries or generators are so connected that they, in effect, form one power source.

Set two separate 5,000 volt generators operating, and you may, with perfect safety, bring the positive of one into direct contact with the negative of the other. The result will be exactly the same as though two dead wires were brought into contact.

Thoroughly insulate a 10,000 volt generator from the ground, including all the wires and apparatus attached to it, and you may with perfect safety stand with your bare feet on wet ground and handle either the raw (uninsulated) positive or negative wire separately. But if the positive or negative be "grounded," and you touch the wire of opposite polarity, the current would leap through your body into the ground and through the ground into the other wire. It does not necessarily follow, however, that when both wires have current carrying connection with the ground, the current will always pass from positive to negative, because the "ground," as it is called, may have such high resistance that the pressure cannot force the current through.

HOW ELECTRICITY IS GENERATED.—In a very large percentage of theatres the projectionist is placed in direct charge of an electric generator. It is therefore essential that he not only understand its handling, adjustment and care from the mechanical viewpoint, but that he also have accurate knowledge of its electrical action and the theory upon which it acts in the generation of electric energy, since

NO MAN CAN INTELLIGENTLY AND EFFICIENTLY HANDLE ANYTHING WHICH HE DOES NOT THOROUGHLY UNDERSTAND, **and the more a man knows about the thing he is handling the better service he can cause it to give.**

Fill a glass jar of any convenient size two-thirds full of water, to which add ordinary sal ammoniac, procurable at any drug store, in the proportion of one pound to the gallon of water. In this solution suspend a sheet of copper having an area of say twenty square inches on each of its two sides. Near to, but not in actual contact with the copper, suspend a piece of zinc of approximately the same superficial area, and the whole will constitute the simplest form of electric generator known, the assemblage constituting what is known as a "wet" battery. If we make electrical connection between the copper and zinc of such a battery, current, generated by chemical action, will flow from copper to zinc, the former being positive (+) and the latter negative (—). A well proportioned battery of this sort will generate about one volt pressure and several amperes of current while it lasts.

In theory it would be possible to join sufficient of these batteries to produce almost any desired voltage and amperage, but in practice this would be impractical. The use of generating batteries is almost entirely confined to light work, such as the ringing of bells and buzzers, the telegraph and like service where comparatively little energy is required.

For power purposes we depend upon the dynamo, or "generator," as it is usually termed. The dynamo depends for its action primarily upon magnetism, and the generation of electric energy in the armature of a dynamo is based upon the following law:

"If an electric conductor in the form of a closed circuit be moved in a magnetic field in such a way that lines of force are cut, a current of electricity will be generated therein, which same will flow in a direction at right angles to the line of motion."

See Hawkins' Electrical Guides, Vol. 1, Pages 125 to 136, for a detailed explanation of this law and its operation.

In Fig. 1 we see the diagrammatic representation of the simplest possible form of electric dynamo. N and S are respectively the north and south poles of a permanent magnet, between and around the poles of which flow magnetic lines of force, represented by the dotted lines. Within the magnetic field thus formed is copper wire A—B, bent

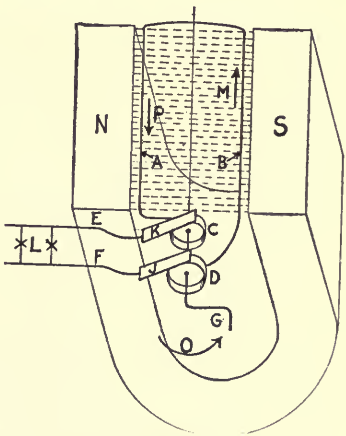


Figure 1

as shown, one end being attached to flat-faced metal ring C, and the other end to a similar ring, D. On the face of each of these rings, and in electrical contact therewith, rest metal brushes J and K. Wires E and F, which represent an outside circuit, connect respectively with brushes J and K. It will thus be seen that wire coil A—B, through ring C, brush K, wire E, lamps L, wire F, brush J and ring D, forms a complete electric circuit.

HOW ARMATURE WORKS.—Now if by means of crank G we rotate coil A—B in the direction indicated by arrow O, coil side A will pass down and side B up through the magnetic field, cutting across lines of magnetic force in so doing. This will (see law before quoted) generate an electric impulse (current) which will, under the conditions, flow through the coil, rings, brushes and circuit in the direction indicated by arrows M and P.

ARMATURES GENERATE A C.—And now a step further. In Fig. I we assume crank G to rotate in the direction indicated by arrow O. Under that condition the current will flow toward brush K, but as the coil is rotated the electric impulse becomes weaker, since the coil sides travel more nearly in the direction of the lines of force, hence cut less of them, until finally side B stands directly over side A, and both are traveling in the same direction as the lines of force, therefore, cutting none of them, so that there is no electric impulse generated.

At this point the wires are "dead." There is no voltage, hence no current. But as we rotate the coil still further, the wires again begin to cut across the lines of force, and the electric impulse is revived and becomes stronger until side B reaches the position formerly occupied by side A, when the voltage is again at maximum. But since the current always flows in the same direction with relation to the magnet poles (see arrows L and M) its direction has now been reversed in the coil itself, and it flows into brush J, instead of brush K, hence around the circuit in the opposite direction.

Remember that the current within the magnetic field always flows in the direction of arrows L and M and that the sides of the coil are constantly exchanging their positions as the coil is rotated, hence the current in the coil and circuit is reversed with each half turn of the armature, or in multipolar machines, every time a coil passes through the field of one of the magnetic poles of the machine.

HOW DIRECT CURRENT IS OBTAINED.—Current flowing continuously in one direction, called "Direct Current" (D. C.), is obtained from armatures which produce alternating current (A. C.) by means of what is termed "commutation," as follows, it being understood that we only intend to explain the principle involved. To set forth in detail the intricacies of of actual practice would require many pages of text, as well as many very complicated illustrations.

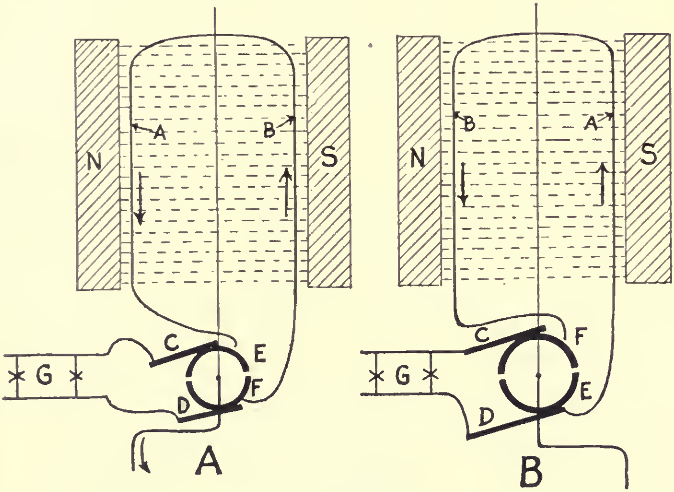


Figure 2

In diagram A, Fig. 2, we see armature coil A—B and a commutator ring split into two sections, E and F, to each section of which an end of coil A—B is attached. Resting upon and in electrical contact with the "commutator" thus formed, are brushes C and D, to which outside circuit G is connected, as shown.

Remembering what has already been said about the direction of flow of the current in armature coils, and assuming it to be in the direction of the arrows, we readily see that under the condition shown in diagram A it will flow into commutator section E, out to the circuit through brush C, and back through brush D. But when the coil has been rotated until coil side B is in position formerly occupied by side A, as shown in diagram B, the current will then flow into commutator section F instead of commutator section E; but since brush C now rests on commutator section F instead of E, the current, while reversed in the coil itself, will still flow in the same direction over the outside circuit, so that we shall have "direct current" everywhere except in the armature of the dynamo itself.

This is called "commutation." Please understand that in Fig. 2 we illustrate the principle involved in commutation only. In modern dynamo armatures there are many coils and commutator sections, bars or segments, as they are variously called, but regardless of complications the principle involved is exactly what we have described. See Hawkins' Electrical Guides, Vol. 1, pages 171 to 180, for a detailed description of the action.

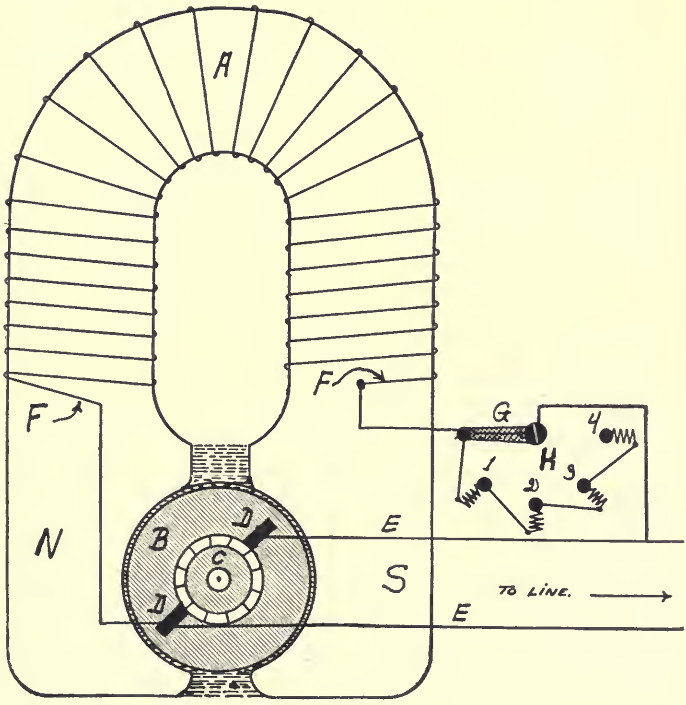


Figure 3

We believe a careful study of the foregoing will enable our readers to understand how current is generated (we use the word "current" for convenience; electromotive force would be more nearly technically correct, but current is expressive, readily understood and short) in a dynamo, how it gets from the armature to the outside wires, and the method by which it is changed from A. C. to D. C., which is all we may reasonably be expected to accomplish along these lines in the limited space available for a discussion of the subject in a work of this kind. Students desiring to examine into the matter in greater detail may do so by consulting the references we have provided. Matter helpful to an understanding of commutation will also be found in Hawkins' Electrical Guides, Vol. 2, pages 237 to 243.

In studying commutation one very important thing to remember is that in practice all armature coils are interconnected with each other through the commutator. Unless this point is understood, the student is apt to be sadly puzzled as to how there can be any connection between positive and negative brushes located at opposite sides of the commutator, when the ends of individual coils may connect to adjoining commutator bars.

Fig. 3 illustrates what is known as a "two pole, direct current, shunt wound generator," or dynamo. N and S indicate respectively the north and south poles of field magnet A. F—F indicates the field winding, which we see coiling around the upper or bowed part of the magnet. B is the armature around and through which pass lines of magnetic force generated by the field magnet. C is the commutator, D—D the brushes, E—E the wires leading to the outside circuit and G the movable lever by means of which the "field rheostat" is adjusted. 1, 2, 3 and 4 are the coils of resistance wire forming the "field rheostat."

The voltage and capacity of the machine described will depend, within certain limits, upon (a) the number of lines of magnetic force passing through the armature, or in other words, the strength of the magnetic field, or in still other words, the density of magnetic flux per square inch of area of the surface of the pole pieces of the magnet which lies next the armature. (b) Number of turns to each armature coil and number of coils the armature carries. (c) Rotary speed of armature, each of which items has directly to do with the number of lines of magnetic force which will be cut per second.

Of course, it is understood that other things, such as the size and winding of the magnets, kind of armature core et cetera, have much to do with the ultimate performance of the machine, but we are merely explaining to you the principle upon which the generator operates, which, with some variations in methods, is always the same.

HOW CURRENT GENERATION IS STARTED.—The magnet of the type of dynamo shown in Fig. 3 is a "permanent" magnet, meaning that it does not become entirely demagnetized when the armature comes to rest. In effect, when lying idle it is just an enormous horse-shoe magnet, much the same, except for its size, as the horse-shoe magnets that children play with. The magnetism retained when the machine is at rest is called "residual magnetism." It is very much too weak to enable a dynamo to build up and maintain a commercial voltage. The most we might hope to accomplish by its use would be to generate perhaps ten volts' pressure.

Examining Fig. 3 we see that wire F—F coils around the upper part of magnet A. It may connect either directly to brushes D—D or to lines E—E a short distance from them. In other words, coil F—F and the armature form a complete circuit, which but for field resistance H would be a short circuit, and is in fact a short circuit when lever G is in position shown. Coil F—F forms what is known as the "shunt field circuit" and the generator shown is a "shunt wound" machine.

It is a well known fact that if a current of electricity is passed through a wire wound upon a magnet in the way wire F—F is wound, the magnet will have its power increased, and that the power of the magnet will increase proportionately as the current is increased until the point of "saturation" (iron is said to be saturated with magnetism when the point is reached where it will receive no more) is reached.

Bearing the foregoing in mind, a dynamo starts generating electro-motive force as follows: First having placed lever G in the position shown, which "cuts out" or eliminates all the resistance of the field rheostat, the switch connecting wires E—E with the outside circuit is opened, so that all current generated must flow around shunt circuit F—F, there being no place else for it to go. Power from an engine or motor is now applied and armature B is rotated at high speed, its coils cutting lines of magnetic force in the weak field of residual magnetism. This immediately creates a slight electromotive force, the current resulting from which flows around shunt field F—F, thus slightly strengthening the magnet, which instantly increases its magnetic flux so that the armature wires cut more lines of force, which in turn strengthens the current flowing over the shunt field.

This process continues until the normal voltage of the machine is reached, whereupon the switch connecting with the outside circuit may be closed, thus connecting the machine with its load, and lever G adjusted, until the resistance of the field rheostat limits the shunt field current flow to the value necessary to maintain the magnetic field at the strength required to maintain the desired voltage.

Modern dynamos for the most part have more than two poles, but that fact does not in the least alter the action as before set forth. The added poles merely serve to secure the same effect with a lower armature speed and with a less massive machine.

DIRECT AND ALTERNATING CURRENT.—Direct current, also known as "continuous current" (though the term is not always correctly applied. See definition p. 25) and commonly abbreviated as "D. C.," acts or flows continuously in one direction. It is commonly considered as flowing from positive to negative. In theory the electric impulse, commonly referred to as "current flow," is outward from the positive brush of the generator, or positive pole of the battery, on one wire of the circuit, along that wire (positive wire because it is attached to the positive brush or pole) to and through the various lamps, motors, et cetera to the negative wire (negative because it is attached to the negative brush or pole of the generator) and along that wire back to the negative pole of the dynamo or battery.

Alternating current, commonly referred to by the abbreviation "A. C.," is the current normally generated in the dynamo armature sent out on the circuit without commutation, so that the current on the entire system reverses its direction exactly the same as it does in the dynamo armature.

WHY A. C. IS USED.—Knowing that D. C. is best for projection, and equally good or even better for incandescent lighting, and that it may be used for power purposes, the novice very naturally inquires why it is not used exclusively.

There are several reasons why A. C. is used, three of which are as follows: First, it is not deemed practical to commutate the current from the armature of a dynamo the voltage of which exceeds 500, because of the difficulty of insulating the commutator bars.

The second reason is that since wattage, which is the measure of electrical power, is the product of volts multiplied by amperes, the size of a wire necessary to convey a given number of horsepower will be much less at high voltage, thus: Suppose we wish to transmit 10,000 watts (746 watts equal one horsepower) at 100 volts. Since volts times amperes equals watts, it follows that watts divided by volts equals amperes; hence, to transmit 10,000 watts at 100 volts would require 10,000÷100=100 amperes, and the power transmitted would be about 13.5 horsepower. But if the voltage were 1,000 instead of 100, then only 10,000÷1,000=10 amperes would be required to convey the required 10,000 watts of power.

To put it another way, 100 amperes at 100 volts represents exactly the same wattage (horsepower) as does 10 amperes at 1,000 volts. To carry 100 amperes requires a No. 3 wire, whereas 10 amperes can be carried by a No. 16 wire; and since a No. 3 wire is .22942 and No. 16 wire .050820 of an inch in diameter, it is readily seen that with high voltage a given wattage (horsepower) can be conveyed on very much smaller wires than could be used were a lower voltage employed. See Hawkins' Electrical Guide, No. 4, page 997, for further details.

Third, still another factor entering into the matter is the fact that once the current has been generated and commuted into D. C., its pressure (voltage) cannot be raised or lowered except by the use of expensive machines having moving parts, thus requiring more or less constant attention, whereas it is quite practicable to attach a very simple device known as a "transformer" (See page 544), which has no moving parts and therefore requires practically no attention, to A. C. lines at any desired point, the action of which will be to raise the voltage to any desired pressure which it is commercially possible to insulate, or to lower it to any required voltage.

It therefore follows that A. C. may be generated at relatively low voltage, "stepped up" by means of transformers to any required pressure, transmitted for long distances over relatively small wires and again "stepped down" to commercial pressures at destination. Or power for commercial purposes may be generated at high voltage, which may be "transformed" to a voltage to suit any commercial requirement at any desired point along the lines.

There are other reasons why A. C. is more desirable for general commercial use than D. C., but those named are perhaps the chief ones.

HOW ALTERNATING CURRENT ACTS.—As already explained, A. C. constantly reverses its action, flowing in one direction for a small fraction of a second, and then in the opposite direction for an equal period of time. Commercial current now in general use in the United States and Canada seldom exceeds 60 cycle and is seldom lower than 25 cycle. Taking 25 cycle current for example, the current would flow in one direction for 1/50th of a second and then in the opposite direction for 1/50th of a second. Each of these periods is called an "alternation," and the two periods together represent what is known as a "cycle." (See definition of "cycle," Page 26.) If the periods of flow were 1/120th of a second, then the current would be called "60 cycle," because there would be 60 complete cycles (120 alternations) per second of time. With a 25-cycle current there are twenty-five complete cycles —fifty alternations—per second.

Electric dynamos may be built to produce almost any desired number of cycles per second (called "current frequency"), but the two standard frequencies used almost universally for commercial work are 25 and 60 cycles per second. The first named is employed where the current is to be converted to D. C., as in the case of street railways, and where the current is to be used mostly for power purposes. Sixty cycle current is used almost universally where the current is to be used extensively for both lighting and power.

Low frequency current (25 cycle) is objectionable for lighting for the following reasons: If a light be produced by very low frequency current there will be a perceptible flicker, due to the fact that the E. M. F. sinks to zero twice during each cycle, with a consequent dimming of the brilliancy of the light, but as the frequency becomes more rapid, the eye is unable to follow the rapid changes of brilliancy and the light appears to be steady. Due to this cause, 25-cycle current has a decided flicker, whereas, insofar as concerns the ability of the eye to detect it, 60-cycle current has none at all.

It is well that the projectionist have at least a fair understanding of these various matters, because he is placed in direct charge of motors and generators of considerable capacity, and of projection light which may be seriously affected by low current frequency. Moreover, in some places and under some circumstance, problems allied to projection may arise which can only be successfully coped with by the man who has an understanding of the things we have just set forth.

The action of A. C. is usually expressed by diagram, similar to that shown in Fig. 4, the meaning of the various details of which we will endeavor to make clear.

It is quite essential that the projectionist learn to "read" such diagrams, because in the study of the details of his profession he will be constantly confronted with them.

In Fig. 4 the straight, horizontal line represents time, as to its length, and zero pressure or voltage, or no voltage at all, with relation to the triangles above and below it. Put in another way, the horizontal line represents the point at which the alternations of the current are completed, and

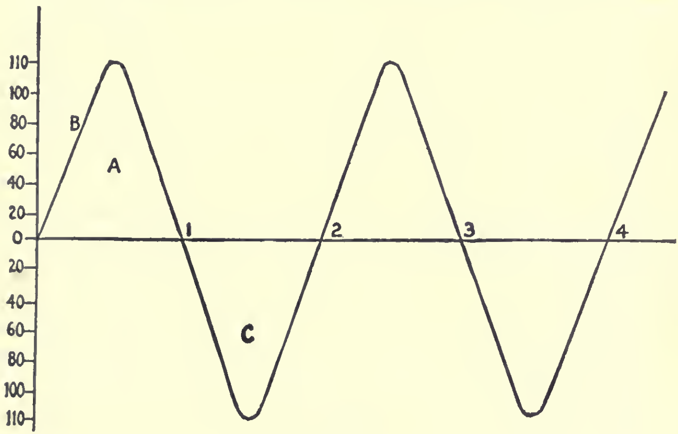


Figure 4.

the voltage and amperage are at zero. Put in still another way, it would represent the point at which the sides of coil sides A—B, Fig 1, stand one above the other, hence cutting no lines of magnetic force and generating no E. M. F.

From 0 to 1 this line represents the time consumed by the current in making one alternation. Triangle A above the line represents the voltage and amperage action during one alternation. At the left of the vertical line the figures represent voltage.

Consider line B of triangle A. As the armature coil begins to cut lines of force, the voltage (and amperage, of course) begins to rise, but time is required to accomplish this. If the current be 60 cycle it will require 1/240th of a second to reach the maximum pressure of 110 volts. Line B in its length represents the gradual rise of voltage. In its slope to the right it represents a lapse of time equal to 1/240th of a second. It will also require 1/240th of a second for the voltage to sink to zero again, as the armature coil gradually passes to the position where for an infinitesimal fraction of time it cuts no lines of magnetic force, which point is represented by the point where the right hand side of triangle A crosses the horizontal line at 1. It therefore follows that from 0 to 1 on the horizontal line represents 1/120th of a second, or one complete alternation—the time the current has been flowing in one direction.

The armature coil now enters the magnetic field from the opposite direction, as is explained in the text accompanying Figs. 1 and 2, whereupon the current begins to flow in the opposite direction and the whole action is repeated, as per triangle C below the line O, triangles A and C representing one complete cycle in course of which 1/60th of a second has lapsed, and the voltage and amperage have twice risen to maximum and twice dropped back to zero. If the current were 25 cycle, then from 0 to 1 would represent the lapse of 1/50th of a second and from 0 to 2 the lapse of 1/25th of a second.

You will therefore see that in reading diagrams of this sort, from right to left means time, and the distance of the triangular or curved lines from the horizontal represents E. M. F., or in other words, voltage and amperage.

When studying diagrams of this character it must be remembered that, while the action is almost inconceivably rapid, still when plain, single-phase A. C. is under consideration twice during each cycle there is absolutely no voltage or amperage on or in the lines.

It is a bit difficult for the mind of the novice to grasp this fact, but it nevertheless is quite true.

"But," the student inquires, "if there is no voltage or amperage, how is it that the light from A. C. is continuous?"

The answer is that the light from single-phase A. C. is NOT continuous in brilliancy. Light is produced by either heating carbon or an incandescent lamp filament to the point of incandescence—white hot—and although the brilliancy of the carbon or filament fluctuates with each alternation of the current, the action is so very rapid that the eye cannot follow or even detect it, except in the case of very low cycle current. The brilliancy of the light from 60-cycle current is not continuous, but to the eye it appears to be so because the eye functions too slowly to perceive action of such tremendous rapidity.

SINGLE, TWO AND THREE-PHASE A. C.—Alternating current may be single-phase, two-phase or three-phase. Suppose we have two generators producing precisely the same frequency (same number of cycles per second), and that their armatures are coupled together by means of a chain belt in such way that when the current flow of one is at zero the voltage of the other is at maximum. As a result we would have "two-phase" current. The voltage of such a circuit is never at zero, because when the voltage of one generator is at zero in the course of the alternations, the voltage of the other is at maximum. The action of two-phase current is represented by diagram A, Fig. 5.

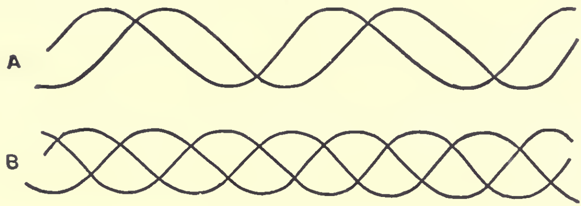


Figure 5.

If we then couple a third generator to the other two, in such manner that the rise and fall of voltage caused by current alternations, as is shown in diagram B, Fig. 5, we shall have "three-phase" current.

Two-phase current ordinarily is transmitted by two entirely separate circuits of two wires each. Its advantage lies in the fact that whereas single-phase current acts intermittently on the armature of a motor, much as does the piston of a single engine on its load, two-phase acts the same as does a double engine, giving a steady pull to the motor armature.

Three-phase current requires only three wires for its distribution. It is the ideal system for transmitting electric energy through any distance for power purposes. It gives a practically steady pull on motor armatures.

For study of these matters in greater detail, we would recommend Hawkins' Electrical Guide No. 4, page 997 to 1,028.

Definitions

IT is desirable that the projectionist know the meaning of certain terms used in connection with his work, hence we append a somewhat extended list of definitions, making no pretense that it is complete. It is merely designed to define those terms with which the projectionist is likely to come more or less frequently into contact. Hawkins' Electrical Dictionary of electrical terms contains more than 500 pages of definitions. It is an excellent work for such as have need for so complete a list.

ABSORPTION OF LIGHT.—The retaining or absorption by a substance, as a lens, of a portion of the light falling upon its surface or passing through it. The energy of the light thus retained ordinarily is transformed into heat, though in some instances its energy is partly absorbed in the working of chemical change. The absorption by good quality glass is about one per cent per inch of distance traversed by the light.

ACETONE.—A liquid obtained as a by-product in the distillation of wood alcohol. It forms the base of some film cement formulas.

ACTINIC RAY.—A ray of light, or of invisible radiant energy which can induce chemical action. The violet and ultra violet rays are the most powerfully actinic of any of the entire spectrum.

ADHESIVE TAPE.—See insulating tape.

A. H.—An abbreviation for ampere hour.

AIR GAP.—Electrically it means a gap or opening in an electric circuit which is occupied by air only, as the gap in a gas engine spark plug.

ALIVE.—A term used to describe the condition of a wire or other thing when charged with E. M. F.

AMMETER.—An instrument for measuring current flow in amperes,. It is also known as the "Ampere Meter." It is the commercial form of the galvanometer.

AMP.—The most commonly used abbreviation for ampere.

AMPERE.—The unit of electrical current flow. See page 51.

AMPERAGE.—The strength of current flow measured in amperes.

AMPERE-HOUR.—One may draw a certain quantity of water, say a gallon, from a hydrant in one minute or in ten minutes, but regardless of the time consumed in drawing the water, it is still one gallon, no more and no less. The same holds true in dealing with electric current. A certain given quantity may be used in one minute, or in ten minutes. The current flowing in any circuit is the relation of the quantity flowing to the time during which it flows. If one ampere of current flows for a period of one hour, then one ampere hour of energy has been consumed; also a flow of two amperes for one half hour would be one ampere hour, as would also a flow of four amperes for a period of fifteen minutes, or a flow of ½ ampere for a period of two hours. Amperes × hours= ampere hours.

AMPERE TURN.—A unit of magneto-motive force equal to the force resulting from the effect of one ampere passing around a single coil of wire.

ANGLE OF INCIDENCE.—See page 222.

ANGLE OF PROJECTION.—The angle the axis of projection (which see) mal es with a horizontal line level with the center of the screen.

ANGLE OF REFRACTION.—See page 222.

ANODE.—As applies to projection, the side electrodes of the mercury arc rectifier tube.

APERTURE, PROJECTOR.—The opening in the aperture plate of a motion picture projector, the edges of which mask the film photograph and give the projected image its outline upon the screen.

APERTURE, PROJECTOR, STANDARD SIZE.—The size of the standard aperture is .906 of an inch wide by .6795 of an inch high, which is equivalent to 29/32 and 87/128 of an inch, respectively.

ARC.—In lighting, an arc is the result of maintaining an E. M. F. between carbons which are somewhat separated, but between which current flows across an "arc stream" composed of the gases generated in the process of volatilization of carbon. The resultant brilliancy comes mostly from the incandescent carbon tips, though the arc stream has some luminosity by reason of the fact that it carries particles of incandescent carbon.

ARC VOLTAGE DROP.—The drop in voltage between the tips of the carbons of an arc lamp, due to overcoming the resistance the current encounters in passing from one carbon tip to the other.

ARMATURE.—In a dynamo or motor a core of metal mounted on a shaft, around or upon which is a winding of wire, the whole being designed to rotate in a magnetic field, cut lines of magnetic force and thus produce electric energy, or power.

ARMATURE COIL.—That portion of the winding of an armature which would be traced in following an armature winding from one commutator segment to the next.

AUTOMATIC FIRE SHUTTER.—The shutter covering the aperture of a projector when it is at rest, the same being raised and held open by the action of a governor, when the projection speed is such that danger of igniting the film is eliminated.

A. W. G.—The abbreviation of "American Wire Gauge," which is also and commonly known as the "Brown & Sharpe" wire gauge. It is the standard in the United States and Canada. It measures wires from No. 40 (diameter .00314 of an inch) to 0000 (diameter .46 of an inch).

AXIS OF PROJECTION.—A straight line from center of film photograph to center of the image on the screen.

BACK END OF ARMATURE.—End opposite from commutator.

BACK FOCUS.—The distance from film to first surface of a projection lens when the picture is in focus on the screen and the illuminant sufficiently distant to illuminate the film with parallel rays of light, as in the case of a film illuminated by the sun. A condition never, of course, met in actual practice. See "Working Distance."

BALANCED ARMATURE.—One which will run without vibration.

BALANCED LOAD.—A load carried by two generators, as in the 3-wire system, is said to be "balanced" when each generator carries an equal load, or when the load is equal on both "sides" of the system.

BEAM OF LIGHT.—A bundle of light rays. A pencil or line of light of greater area of cross section than a single ray.

BLOWING A FUSE.—The melting of a fuse, usually due to overload, though it may be caused by mechanical heat generated by poor electrical contact of the fuse with its contacts.

BLOWING POINT.—The number of amperes (flow of current) necessary to blow a given fuse is the "blowing point" of that fuse.

BRUSH.—A device for making electrical contact between the rotating commutator, or collecting rings of a generator, and the stationary circuit wires. Brushes are made from carbon, copper wires, copper strips and copper gauze, but carbon brushes are most largely used.

BRUSH LOSS.—Loss, in watts, due to lack of perfect electrical contact between brush and commutator or collector ring. May be greatly increased by dirty brushes, dirty, rough commutator or lack of sufficient pressure between brushes and commutator.

BRUSH ROCKER.—The rocker or yoke to which dynamo and motor brush holders are attached. Its purpose is to permit the shifting of the brushes around the commutator to the neutral point.

BUS BARS.—Name commonly applied to the heavy copper bars used on switchboards where a large number of circuits are to be served. Strictly speaking, this name may only be properly applied to power house heavy copper bars connecting with the generators.

BUZZER.—An electric signal which makes a buzzing sound.

B. X.—A flexible metal tubing for the protection of electric wires, much used for interior work. A flexible metal conduit.

CABLE.—A single copper wire, or strand of such wires, heavily insulated and covered with a metal sheath, usually of a lead composition.

CALCIUM LIGHT.—An intense white light produced by the incandescence of a spot on a pencil of lime when a mixture of oxygen and hydrogen gases is burned in contact therewith. Also called "lime light." Used for projection where electric current is not available, but is a very unsatisfactory illuminant for motion picture projection as compared with electric light.

CALIPERS.—Instruments with which to measure external and internal diameters.

CAM.—A revolving disc fixed to a shaft and designed to impart to a second element, with which it is in constant or intermittent contact, a variable velocity or motion, or an intermittent motion.

CAMERAMAN.—The one who does the actual photographing in the production of motion pictures.

CANDLE.—The unit of illumination, as one candle power.

CANDLE FOOT OR FOOT CANDLE.—A unit of illumination, being the light given by a British standard candle at one foot distance. It is equal to 10.764 candle meters, which see.

CANDLE METER.—A unit of illumination, being the illumination of a standard candle at the distance of one meter.

CANDLE, STANDARD.—The standard candle by which all lights are measured is legally held to be a sperm candle consuming 120 grains of wax per hour. In practice standardized incandescent lamps are more reliable. The standard unit of candle power established by the National Bureau of Standards at Washington equals 100/80ths of the Hefner unit under Reichsanstalt standard condition.

CARBON ARC.—A voltaic arc occurring between carbon points, as in an arc lamp.

CARBON BRUSHES.—Commutator brushes made from carbon, sometimes coated with copper to insure better electrical contact with holders.

CARBON ELECTRODES.—The carbons used in an arc lamp.

CARBON JAW.—The jaw of an arc lamp by means of which the carbons are gripped and held.

CARBONS.—The carbon rods or pencils used in an arc lamp.

CARRYING CAPACITY.—Greatest number of amperes an electrical conductor can safely carry.

CARTRIDGE FUSE.—See page 109.

CATHODE.—In projection the lower, mercury, contact of a mercury arc rectifier tube or bulb.

CELLULOID.—A hard, flexible substance formed by dissolving camphor in alcohol and adding pyroxylin. The resultant mass is incorporated between rollers.

CEMENT, FILM.—A cement, or chemical solvent, by means of which two pieces of film may be joined or spliced together. All film cements are volatile, therefore must be kept tightly corked when not in use.

CEMENT LINED CONDUIT.—Conduit having its interior surface coated with cement.

CENTER LENS.—The lens between the collecting and converging lenses in a 3-lens condenser combination.

CHANGE-OVER.—In projection, the act of changing from one projector to another without interrupting the continuity of action upon the screen.

CHATTERING BRUSH.—The rattling of a brush on the face of a commutator, usually caused by the same being loose in holder.

CHOKING COIL.—(Commonly called "choke coil"). A coil of wire wound on an iron core so as to give self-inductance with small resistance, used on A. C. to impede the current with slight loss in power, also called an "impedance coil" or "reactance coil."

CHROMATIC ABERRATION.—See page 130.

CIRCUIT BREAKER.—A device, somewhat similar to a switch, by means of which a dangerous variation in current flow will operate electro magnets and open the circuit. Circuit breakers are made to operate both for over- and under-load.

CIRCULAR MEASURE.—Every circle is divided into 360 equal parts, called degrees. A degree is 1/360th the circumference of a circle, regardless of the diameter of the circle, hence a degree has no set dimension as to its width or length, but increases in width or length with every increase of circle diameter. Each degree is subdivided into 60 minutes, and each minute into 60 seconds.

CIRCULAR MILL.—The area of a circle, 1/1000th of an inch in diameter. The square of the diameter (multiplying diameter by itself) of any circle, in mills (thousandths of an inch) gives its area in C. M.

C. M.—Abbreviation for circular mill.

CLOSED CIRCUIT.—A circuit in which continuous contact permits a constant flow of current.

COLLECTING RINGS.—Rings of A. C. generator upon which the brushes rest, and from which the current passes into the brushes and thence to the outside circuit.

COLLECTOR LENS.—The lens of the condenser combination which is next the light source.

COMBINATION PROJECTOR.—A motion picture projector equipped with a stereopticon attachment.

COMMUTATOR.—An arrangement of copper commutator bars by means of which the alternating current of the armature is changed to direct current in the outside circuit.

COMPOUND WINDING.—A method of winding a dynamo or motor field magnet with two sets of coils, one of which forms a shunt circuit, the other carrying the entire output of the armature, except what flows through the shunt circuit.

CONDENSER.—In projection, a combination of lenses designed to collect the diverging rays from the light source, and to refract and converge them upon the projector aperture.

CONDUCTOR.—(a) Any substance which will transmit electric current, though the name is ordinarily only applied to those having low resistance. (b) A wire or a copper bar used to transmit electrical energy.

CONDUIT.—A metal or armored tubing in which electric wires are placed for their protection.

CONJUGATE.—United in pairs; yoked together; coupled.

CONJUGATE FOCI.—See page 127.

CONNECTOR.—A device for joining wires electrically in such manner that they may be readily released.

CONSTANT CURRENT DYNAMO.—A dynamo so wound that it will deliver constant amperage under varying load. Such a generator varies its voltage instead of its amperage.

CONTINUOUS CURRENT.—A non-pulsating current which is constant both as to pressure and direction of flow. See Direct Current.

CONVERGING LENS.—The lens of a condenser combination which is farthest away from the light source.

COPPER.—Next to silver the best metallic conductor of electricity and of heat known.

COPPER LOSS.—The loss of energy resulting from resistance offered to the flow of current through a copper wire. See Voltage Drop.

CORED CARBONS.—Projection carbons having a core composed of ground, baked carbon, mixed with a suitable binder, usually water glass.

COVER GLASS.—The glass which covers the photograph on a stereopticon slide.

C. P.—The abbreviation for candle power.

CRATER OF ARC.—The concave depression produced on the tip of the positive carbon of arc lamps by action of the current.

CRATER ANGLE.—The angle at which the crater is with relation to the axis of the optical train. The most efficient angle is 55 degrees.

CRATER PROJECTOR.—A means for projecting an image of the crater. It may be a pin hole in the lamp house door in conjunction with a lens, or merely a pin hole, or a pin hole, a lens and a reflector to direct the image to any desired spot.

CRITICAL ANGLE.—The angle of incidence beyond which rays of light are no longer refracted into a transparent medium, but are reflected from its surface.

CYCLE.—A series of operations. As applied to A. C., the cycle is two complete alternations.

DIMMER.—An adjustable resistance inserted in an incandescent circuit by the manipulation of which the lights of the circuit may be gradually dimmed or brightened.

DIOPTER.—The unit for expressing the refractive power of a lens. It is the power of a lens whose focal length is one meter.

DIRECT CURRENT (D. C.).—A current constant in direction, though not necessarily in value. A direct current constant both in direction and value is called a continuous current. Direct Current, which, while continuous in direction, pulsates as to pressure, is often wrongly called continuous current.

DIRECT CURRENT CONVERTER.—A machine for converting D. C. of one voltage to D. C. of a different voltage.

DISSOLVE.—The gradual transition or fading of one projected image into another.

DIVERGING BEAM.—A light beam which diverges away from its immediate source.

DOUBLE THROW SWITCH.—A knife switch which may be thrown over into either of two sets of contacts.

D. P. SWITCH.—Abbreviation for double pole switch.

DEGREE.—A unit of measurement of temperature.

DEGREE.—The circumference of every circle is divided into 360 equal parts called degrees, hence a degree is 1/360th part of the distance around the circumference of any circle. It is, therefore, evident that with every increase or decrease in circle diameter the linear measurement of a degree changes, insofar as applies to that particular circle. Each degree is divided into sixty equal parts, called minutes, and each minute is divided into sixty seconds.

DENSITY OF FIELD.—The quantity of electromagnetic lines of force existing in a unit of cross section area of an electro-magnetic field.

DETERIORATION OF INCANDESCENT LAMP.—The decrease in candle power of an incandescent lamp which takes place after prolonged use.

DIFFERENTIAL WINDING OF FIELD.—A method of winding a field magnet with double coils in such a way that each exerts a pull against the other.

DIFFUSION.—As applied to light, its reflection by a surface in such a way that it is scattered. See page 222.

DIRECT COUPLED DYNAMO.—One having its armature shaft coupled direct to the shaft of the source of power which drives it.

DIRECT CURRENT DYNAMO.—A dynamo supplying direct current, which may or may not be continuous current.

DIRECTOR.—One who directs the actors during the making of a scene or scenes of an entire production.

DOUBLE POLE SWITCH.—A switch which controls both wires of a two-wire circuit, as a two-blade knife switch.

DOUBLE THROW SWITCH.—A knife switch which may be thrown over into either of two sets of contacts, thus connecting its center contacts to either of two entirely different circuits.

DOUSER.—A manually operated shutter in the lamphouse or in the condenser cone by means of which the light may be intercepted before reaching the spot, or, in the case of a stereopticon, the lens.

D. P. SWITCH.—An abbreviation, meaning double pole switch.

DROP IN POTENTIAL.—A drop in voltage due to resistance of the lines. May be due to length of lines or to overload.

DRY CELL.—A battery or primary cell usually made up of a jar composed of zinc, which forms one of the elements or electrodes. The other element is of carbon, suspended so that it cannot come into contact with the zinc. The remaining space is filled with an absorbent substance saturated with sal ammoniac.

E. E.—Abbreviation for Electrical Engineer, a degree conferred upon students by technical schools when they have completed a course in electrical engineering.

EFFICIENCY.—As applied to motors, generators and transformers, the ratio of power applied at the input terminals to the power available at the output terminals. It is found by dividing the watts output by the watts input, thus: If the input of a motor be 10 amperes at 110 volts, or (100 x 10) 1100 watts, and the output be 900 watts, the efficiency of the motor would be $900 \div 1100 = 81 +$ per cent.

ELECTRODES.—In arc lighting, the carbons which form the terminals of the lamp.

ELECTRO MOTIVE FORCE.—That force which creates and maintains an electric current in, on or through a conductor.

It is commonly termed voltage. It is measured in volts. It is abbreviated E. M. F.

EQUIVALENT FOCUS.—See page 129.

EXCHANGE.—A central repository from which film may be had, usually on a rental basis.

EXHAUST FAN.—A fan used to pull or pump air out of a room, or other inclosure; a fan designed to create a vacuum.

F.—Abbreviation for Fahrenheit. On its scale 32° represents the melting point of ice and 212 the boiling point of water at sea level.

FADE-IN.—The gradual appearance of the picture from darkness to full brilliancy.

FADE-OUT.—Opposite from fade-in, which see.

FEATURE.—A photoplay to be used as the leading part of a theatre bill or program.

FIELD MAGNETIC.—The space occupied by magnetic lines of force.

FIELD COILS.—The coils of wire wound on the field magnets of a dynamo.

FIELD MAGNETS.—In a dynamo or motor the magnets forming the magnetic field in which the armature revolves.

FIELD POLES.—The poles of the magnets in the field of which the armature revolves.

FIELD RHEOSTAT.—An adjustable resistance used to control the amount of current flowing in the field coils of a dynamo or motor, hence an adjustable resistance by means of which the strength of the magnetic field is varied.

FILM.—In projection, a ribbon of celluloid upon which the photographs constituting a motion picture are carried.

FILM CEMENT.—See Cement.

FILM MENDER OR SPLICER.—A device used to correctly join the sprocket holes and clamp the ends of the film together when splicing film.

FIXED RESISTANCE.—A resistance having a given, fixed value, as a non-adjustable rheostat.

FLAMING OF ARC.—In projection a flame emanating from the tips of the electrodes of an electric arc under certain conditions. Its cause may be any one of several things, including impure carbon, carbons working above capacity, high amperage and a too great distance between carbon tips.

FLAT COMMUTATOR SEGMENT.—A commutator segment which has become flat through wear, burning or faulty adjustment.

FLATS.—Spots on commutator which have become flat, or slightly depressed through wear, or from other cause.

FLOATING BATTERY.—A storage battery so connected to a parallel system that it will be charged by it or to automatically discharge into it, as required.

FOCUS.—The point of concentration. The point at which light rays meet and form an image after being subjected to the action of a lens.

FOCUSING SCREW.—Thumbscrew by means of which the projection lens is moved forward or backward to focus the image on the screen.

FOOT CANDLE.—A unit of illumination; the light of a standard candle at a distance of one foot.

FOOTAGE.—Film length measured in feet.

FRAME (noun).—A single photograph on a motion picture film.

FRAME (verb).—To so adjust the projector framing device that the film photograph is in correct register over the aperture.

FRAME LINE.—The line between the top of one image and the bottom of the next in a motion picture film.

FREQUENCY.—The number of double alternations per second, commonly referred to as "cycles."

FRICTIONAL LOSS.—In any machine the amount of energy expended in overcoming the resistance caused by the friction of its various parts.

FRONT END OF ARMATURE.—The commutator end.

FRONT WALL.—As applied to the projection room, the wall next the screen. As applied to the auditorium, the wall at the stage or screen end.

FUSE.—See page 107.

FUSE ALLOY.—See page 107.

FUSE BLOCK.—A slab or "block" of insulating material carrying one or more fuses.

FUSE LINKS, OR LINK FUSES.—See page 111.

GAS STREAM.—The stream of gas between the carbon tips of an arc lamp. It is formed by the volatilization of carbon and has considerable conductivity as compared with the surrounding air.

GENERATOR.—Same as dynamo, which see.

GERMAN SILVER.—A metal alloy composed of copper, zinc, and nickel in varying proportions. Much used for resistance wire where a uniform resistance at varying temperatures is important.

GLASS.—A substance made by melting together sand or silica with lime, potash, soda or lead oxide. By varying the proportions of these ingredients different kinds of glass are obtained, such as bottle, plate, flint, crown, etc.

GRAPHITE.—One of three forms in which carbon occurs in nature. Also called plumbago. Useful to the projectionist as a lubricant for the arc lamp, since it is an excellent lubricant and is but little affected by high temperature.

GRID.—As applied to projection, one resistance of a grid rheostat. See figure 132, page 416.

GROUND.—(a) Broadly it is a term used to designate a current carrying connection of such high resistance that it is not a short circuit, but which nevertheless enables the current to reach opposite polarity without traveling its allotted path. (b) An electrical contact of one or both polarities with earth. (c) An electric contact of one polarity with something it is not intended shall be electrified.

GROUND WIRE.—In projection a wire connecting a projector frame with earth.

HARD SOLDER.—A solder which melts at red heat only. May be made from zinc and copper.

HIGH COMMUTATOR BAR.—A condition where one or more bars or segments of a commutator are higher than the others. Unless remedied it will work very serious harm to the commutator.

HORIZONTAL CANDLE POWER.—Illuminating power of a light source in a horizontal direction.

HORSE POWER.—One horse-power (h.p.) equals 33,000 foot-pounds of work per minute. It is the theoretical amount of work one strong draft horse is supposed to perform if a block and tackle be attached to a weight of 33,000 pounds and the tackle be of such proportion that the horse can, by exerting his full strength, just raise the 33,000 pounds one foot while walking outward pulling on the rope for a period of one minute. Under these conditions one horse-power has been exerted during that minute. That is the theory of the thing. One horse-power-hour is the amount of work exerted by one horse during one hour, or by 60 horses during one minute, or by 3600 horses during one second. In electrics 746 watts is supposed to represent the raising of 33,000 pounds one foot in one minute, or, in other words, one horse power. The unit was established as follows: 1 watt is equivalent to 1 joule per second (the joule is the practical C. G. S. unit of electrical energy. One joule is equal to .73734 of a foot-pound, or, .00134 h.p.-seconds; it is the quantity of electric energy necessary to raise the potential of one coulomb of electricity one volt in pressure) or 60 joules per minute, and 1 joule is equal to .73734 of a foot-pound, therefore 60 joules = 60 × .73734 = 44.24 foot-pounds. Now, since one horse-power equals 33,000 foot-pounds per minute the electrical equivalent would be 33,000 ÷ 44.24 = 746 watts.

HOUSE SERVICE WIRES.—The wires connecting the main house cutout with the street mains or transformer.

IMAGE.—In projection optics an image is an image or picture of an object (transparent photograph on film or slide) formed on a receiving surface called a screen, by light rays focused by a lens.

INCLOSED SWITCH.—A knife switch inclosed in a metal housing for the protection of its live parts.

INDUCTION.—The influence which a mass of iron charged with A. C. exercises upon surrounding bodies of metal, without having any actual metallic connection therewith.

INSULATION.—The employment of substances having high resistance to confine electric current to the conductor, and prevent it escaping to a conductor of opposite polarity. Rubber, porcelain and glass are examples of high resistance insulating materials.

INSULATING TAPE.—A cloth tape impregnated with an insulating compound, usually composed of coal tar and resin in proportions of about 30 to 40. The compound causes it to be adhesive. It is used to insulate wire splices, etc.

INTERMITTENT MOVEMENT.—The mechanism by means of which the intermittent sprocket is operated.

INTERMITTENT SPROCKET.—The sprocket of a projector by means of which the film is given its intermittent movement at the aperture.

KILOGRAM.—A unit of mass in the metric system. It equals 2.2064 pounds.

KILOMETER.—1,000 meters; 3,280.899 feet; or .62138th of a mile.

KILOWATT.—One thousand watts, which equals 1.34 horsepower.

KILOWATT HOUR.—The use of one kilowatt of electric energy for one hour.

KNIFE SWITCH.—A switch having a movable blade or blades, usually of copper, which are hinged at one end and make or break contact with parallel spring contact clips at the other. The switch blade takes the place of the conductor between its contact points.

K. W.—Abbreviation for kilowatt.

K. W. H.—Abbreviation for kilowatt hour.

LAMP ANGLE.—The angle at which the projector lamp, as a whole, sets with relation to the axis of the projector optical train.

LAMPHOUSE.—The metal housing surrounding the light source and carrying mount for the condenser lenses.

LAMPHOUSE VENT PIPE.—The pipe leading from the lamphouse to the open air, or to some flue connecting therewith, by means of which the heat and gases generated inside the lamphouse are removed from the projection room.

LEADER.—A short length of film attached to the leading title of a subject, or to the beginning of a reel of film, in order to protect it and to allow of threading into the take-up without using the film title for the purpose.

LENS.—(a) A transparent medium, usually glass, having one or more curved surfaces, for the purpose of changing the direction of rays of light, giving them a direction largely determined by the curvature of the lens surface or surfaces. (b) A combination of single lenses mounted together so as to act as a single (compound) lens.

LENS JACKET.—The outer part of a projection lens, which usually carries the focusing mechanism and holds the inner lens tube in which the lenses are mounted.

LENS PORT.—The opening in the front wall of the projection room through which the beam from the projection lens passes.

LENS, PROJECTION.—See "Projection Lens."

LIGHT BEAM.—See "Beam of Light."

LIGHT RAY.—A thin line of light having no appreciable area of cross section.

LOOP.—In projection, the slack film left between the upper sprocket and the top of the gate tension shoes, and between the lower end of the gate tension shoes and the lower sprocket, in order that the film between the two loops may stop and start intermittently while the rest of the film has continuous motion.

MAGNET.—In the ordinary acceptance of the term, a body of iron charged wtih magnetism and generating a magnetic circuit or field. A magnet may be a permanent magnet (a polarized electro-magnet), in which case the magnetic field is always present in considerable strength, or it may be an electro-magnet only when "excited" by passing a current of electricity over wires wound around it. Magnets, either permanent or otherwise, may be made more powerful by passing an electric current over wires coiled around them.

MAGNET COIL.—A coil of insulated wire wound around an electro-magnet, over which current is passed in order to increase the density of the magnetic field produced by the magnet. Also called "Field Coils."

MAGNET CORE.—The bar of iron or steel around which the magnet coil is wound.

MAGNETIC DENSITY.—The number of lines of magnetic force passing through a magnetic field per unit of cross section area.

MAGNETIC FIELD.—(a) The space immediately surrounding the poles of a magnet through which the magnetic force acts. It is strongest near the surface of the magnet poles, decreasing rapidly in strength with distance, finally disappearing entirely. (b) The space immediately surrounding any wire conveying alternating current.

MAGNETIC FLUX.—The average intensity of a magnetic field multiplied by its area. The total strength of a magnetic field.

MAINS.—A term variously used, but commonly designating the wires of the principal distribution circuits of an electric system.

MAINS, STREET.—The wires of the street circuit which supplies the house service wires.

MAT.—In projection, the paper mask used to outline the photograph of a stereo slide.

MEAN SPHERICAL CANDLE POWER.—The average spherical candle power.

MELTING POINT.—The temperature at which substances begin to melt or fuse. An alloy consisting of one part tin and one part lead, melts at from 375 to 460 degrees. Tin melts at from 442 to 446 degrees.

Lead melts at from..............	608 to 618	degrees
Silver melts at from.............	1733 to 1873	"
Copper melts at from............	1929 to 1996	"
Steel melts at from..............	2372 to 2532	"
Wrought Iron melts at from.....	2732 to 2912	"

MENISCUS.—A lens which is convex on one surface and concave on the other.

METER.—The unit of length in the metric system. Equals 39.37 inches.

METER.—An instrument for measuring.

MICA.—A mineral substance, mined in certain places. It is semi-transparent, may be split into very thin sheets and has high insulating and heat resisting powers. It is used for projection arc lamp insulation.

MIL.—A unit of length. 1/1000th of an inch.

MIL-FOOT.—A wire one mil in diameter and one foot in length.

MIL-FOOT STANDARD.—The standard of resistance in wires. See page 73.

MISFRAME.—In a film a wrongly made splice through which a part of one photograph is eliminated. In projection the showing of a portion of two pictures on the screen at the same time.

MOTOR, ELECTRIC.—A machine for transposing electrical power into mechanical power.

MOTOR GENERATOR.—In projection, a machine consisting usually of an A. C. motor direct connected to a D. C. generator for the purpose of generating D. C. with power supplied by A. C. The resultant D. C. may be of higher, lower, or the same voltage as the A. C. supply, but for projection work it is, in modern and efficient machines, supplied at arc voltage by a generator wound for constant current. Also see "Rotary Converter." Motor generators are also used in projection for the purpose of reducing D. C. supply to projection arc voltage.

MOTOR GENERATOR SET.—See "Motor Generator."

MULTI-PHASE.—A term applied to any A. C. system having more than one phase. Polyphase is the term more commonly employed.

MULTIPLE REEL.—A photoplay several reels in length.

NAILS.—Nails are used everywhere. The following table will be useful:

Size	Length	No. of Nails to Lb.
3 penny	1-inch	557
4 penny	1¼-inch	353
5 penny	1 2/3-inch	232
6 penny	2-inch	167
8 penny	2½-inch	101
10 penny	2¾-inch	88
12 penny	3-inch	54
18 penny	3¼-inch	44
20 penny	3½-inch	34
Spikes	4-inch	16

NATIONAL ELECTRIC CODE.—A national code of rules based on the requirements of the fire underwriters. The requirements of the code must be observed as to inside electric wiring and other work in order to get insurance on a building. Copies of the code may be had by applying to the National Board of Fire Underwriters, Electrical Department, Room 1100, No. 123 William Street, New York City. It is sent free of charge, but we would suggest that you send five cents in stamps for postage. It is a 216-page book.

NEGATIVE.—The opposite to positive. In electrical apparatus the pole toward which the current is presumed to flow.

NEGATIVE CARBON.—In a D. C. arc lamp the lower carbon to which the current flows across the arc from the positive carbon.

NEGATIVE FILM.—The film which is exposed to light in the camera. The film upon which the original image is impressed. The film from which positive prints are made.

NEGATIVE POLE.—Opposite pole to positive. In a dynamo or battery the pole to which the current is presumed to return from the external circuit.

NEGATIVE WIRE.—A wire attached to the negative pole. A wire having negative potential.

NEUTRAL WIRE.—In a 3-wire system the center wire or conductor is the "neutral.' It is negative to one outside wire and positive to the other. when either side is used separately.

NEUTRAL WIRE AMMETER.—An ammeter connected into the neutral wire to determine how nearly the load is in balance. It may be attached to any circuit or to the service wires of any building, if desired. The amount it records is the amount the load is out of balance.

NICKEL STEEL.—Ordinary soft steel to which a small percentage of nickel has been added. Best results are had with about 3.25 per cent. of nickel.

OBSERVATION PORT.—The opening in the front projection room wall through which the projectionist views the screen.

OHM.—The unit of resistance. See page 53.

OHM'S LAW.—The law that, considering a uniform flow of current in a given circuit, the amperage is equal to the E. M. F., in volts, divided by the resistance in ohms. The law is expressed by simple formulas. See page 55.

OIL WELL.—(a) An oil-tight receptacle in which the intermittent movement of a modern projector is placed so that it may work in an oil bath. (b) A cavity under a dynamo or motor bearing which contains oil for lubrication of the bearing. See "Ring Oiling."

OPEN CIRCUIT.—A circuit which is not complete as to electrical connection. A circuit which has been broken, as by the opening of a switch.

OPTICAL AXIS.—A line passing through the center of a lens which is perpendicular to its plane. In a projector optical train a line from the center of the light source to the center of the front lens of the projection lens, when all elements are in proper adjustment.

OPTICAL TRAIN.—In a projector, the various lenses it employs referred to as a whole.

OUTLET.—A point in ceiling or wall out of which wires are led to make connection with lamps, motors, etc.

OUTLET BOX.—An iron box, usually circular in form, located at an outlet to protect the splices and to serve as an anchorage for the circuit conduit.

OUT OF FOCUS.—When the image is not sharp on the screen. See page 146.

OUTPUT.—The electrical energy delivered by a dynamo.

OUTSIDE TRANSFORMER.—Transformer by means of which the service wires of the theatre are fed. Usually referred to as the pole transformer.

OUTSIDE WIRING.—Wiring attached to the surface—not concealed.

OVERLOAD.—A load greater than a machine is designed to carry.

OVERLOAD CAPACITY.—The amount of overload an electrical device or a machine may carry, either permanently or for a stated period, without sustaining permanent injury.

OVER-SHOOTING.—The carrying of the film too far by momentum, due to lack of sufficient tension by the gate tension springs. Failure of the film over the aperture to stop exactly when the intermittent sprocket stops.

OZONE.—A gas of a faint bluish tint and a characteristic odor. It is produced by passing a current of electricity through air, changing the oxygen to ozone. It has purifying and sterilizing properties.

PANEL BOARD.—Name applied to a small distributing switchboard, usually located in the wall of a room, auditorium or hallway, and controlling several circuits, or perhaps all the circuits on a single floor.

PANEL BOARD FEEDERS.—Circuit wires attached to the panel board bus bars.

PANEL BOARD FUSES.—Fuses controlling the circuits controlled by a panel board.

PARALLEL CONNECTION (also called Multiple Connection).—(a) A circuit in which two or more incandescent lamps are connected between the two wires of the circuit. (b) The connection of the two projection arc lamps in such way that both positives are connected to positive and both negatives to negative, with but one rheostat for both lamps. Under this condition both lamps cannot be burned at one time. When the carbons of the idle lamp are brought into contact the other arc goes out. (c) As applies to rheostats on a projection circuit, a connection made in such a way that the wire from the supply connects to one terminal of both rheostats and the wire leading to the lamp to both of the other rheostat terminals. See page 426.

PERFORATIONS.—Holes punched in film which engage with projector sprocket teeth and give film its movement. Commonly called "sprocket holes."

PERMANENT GROUND.—See page 346.

PHASE SPLITTER.—A device for producing two currents from single phase current which will differ in phase, the purpose being to assist in starting a single phase induction motor.

PHASE SPLITTING.—The process of changing a single phase current into polyphase currents.

PHOSPHOR BRONZE.—An alloy of copper, tin and from 2 to 5 per cent. of phosphorus. This alloy is superior to pure copper in strength, but lacks conductivity as compared to copper. It is very durable, and is used for projector wearing parts by some manufacturers.

PLANO.—A term used in connection with lenses. It means a flat surface.

PLANO CONVEX.—A lens which is flat on one side and convex on the other.

PLUMBAGO.—See "Graphite."

POLARITY.—See page 3.

POLARITY SWITCH.—A D. P. D T. knife switch so wired that throwing it over reverses the polarity of the wires of the circuit it controls. See page 350.

POLYPHASE CURRENTS.—Same as two and three-phase currents, which see, page 18. Any current having more than a single phase.

PORT.—In projection, an opening in the front wall of the projection room.

POSITIVE.—As applied to photography, a "print" from a negative. The films used in projection are positive prints.

POSITIVE BRUSHES.—The commutator brushes of a dynamo or motor which connect with the positive wire of the circuit.

POSITIVE CARBON.—In a D. C. arc lamp the upper carbon; the carbon to which the positive wire of the circuit is attached.

POSITIVE PRINT.—Film exposed to light passing through a negative. The film used in projection is a "positive" print.

POSITIVE POLE.—The positive (+) terminal of a generator from which the current is assumed to flow out to the external circuit.

POSITIVE WIRE.—The wire connected to the positive pole of an electric generator and charged with positive (+) E. M. F.

POWER.—The rate at which work is done, meaning work divided by the time in which it is done. The generally accepted unit is the horsepower, which is 33,000 foot pounds a minute. See "Foot Pound."

PRIMARY COIL.—In a transformer, a coil consisting of many turns of insulated copper wire wound around one "leg" of an iron core, or placed within a laminated iron core. In effect it is a powerful choke coil, its practical purpose being to create a magnetic field in order that a secondary current may be induced in a secondary coil placed within the magnetic field thus created, the voltage of which latter will be dependent upon the relative number of turns of wire in the two coils.

PRIMARY CURRENT.—The current in the primary coil of a transformer.

PROJECTION ANGLE.—See page 255.

PROJECTION DISTANCE.—Distance from projection lens to screen. Commonly referred to as "throw."

PROJECTION LENS.—The lens combination which forms the image upon the screen. The lens of a projector optical train corresponding to the objective in a camera. Also termed "projection objective."

PROJECTION SPEED.—The speed at which the film is projected, expressed in feet a minute.

PROJECTION SPEED, NORMAL.—Normal speed of projection as fixed by the Society of Motion Picture Engineers is 60 feet of film a minute.

PROJECTION SPEED, PROPER.—The proper projection speed is a speed exactly equal to the camera speed at which any individual scene was taken.

PROJECTION LAMP.—An arc lamp provided with adjustments necessary to maintain the light source in correct relation to the optical train of the projector.

PROJECTIONIST.—A person who makes the projection of motion pictures his or her profession, trade or business. More particularly the title is applied to ambitious, energetic men of recognized ability in both practical projection and in technical knowledge as applied thereto.

PROJECTOR, MOTION PICTURE.—A combination of a light source, its housing, an optical train and a mechanism and a supporting base, with the necessary means for adjustment of the various elements with relation to each other, the whole being used for the projection of motion pictures.

PROJECTOR MOTOR SWITCH.—The switch attached to a projector by means of which the circuit operating its driving motor is opened or closed.

PROJECTOR TABLE SWITCH.—The switch attached to the projector by means of which the projector light source circuit is opened or closed.

PUSH BUTTON.—A single pole contact switch for low voltage circuits which is operated by pushing a button.

QUICK BREAK SWITCH.—A switch operated by a spring in such way that the contact is broken instantaneously.

QUIET ARC.—An electric arc which is noiseless in operation.

RACING.—As applies to a motor or dynamo, the acceleration of speed which occurs when the machine is suddenly relieved of its load.

RADIUS.—A straight line drawn from the center of a circle to any part of its circumference. The distance from the center of a circle to its circumference. Half the diameter of a circle.

RAIN.—Scratches in film which when filled with dirt become semi-opaque and have the appearance of "rain" in the projected picture.

RATIO OF INTERMITTENT MOVEMENT.—The ratio of the time the intermittent sprocket is in movement to the time it is at rest during each cycle of the intermittent movement action. It is properly expressed in degrees. A 60 degree movement would be one in which the driven member is in motion during 60 degrees of the revolution of the driving member, hence the intermittent sprocket is in movement during that portion of the cycle. It would correspond to a 5 to 1 movement, in which the total period is divided into 6 equal periods, during one of which the intermittent sprocket is in movement. Similarly a 6 to 1 movement would correspond to a 50 (about) degree movement, the total period or cycle being divided into 7 periods.

RATIO OF TRANSFORMATION.—In a transformer it is the ratio of the number of turns in the primary coil to the number of turns in the secondary which establishes the relation of the voltage and current of the secondary to the voltage and current received by the primary. The relation of primary and secondary turns is expressed as follows: Primary voltage : secondary voltage = primary turns : secondary turns. Primary current : secondary current = secondary turns : primary turns. If there be more turns of wire in the primary than in the secondary the secondary voltage will be reduced and the secondary amperage increased, and vice versa. If there be 10 times as many turns in the primary coil as in the secondary coil, then the ratio will be 10 to 1, and the secondary voltage will be only 1/10th that of the primary, while the amperage will be 10 times greater. It will thus be seen that, allowing for no loss in the transformer, the wattage of primary and secondary is always equal.

REACTANCE COIL.—See "Choking Coil."

RECEPTACLE.—A wall socket for an incandescent lamp.

REEL.—The flanged spool upon which film is wound for shipping and for use in projection.

REEL OF FILM.—The footage carried upon a single reel built to carry 1,000 feet of film, when the said reel is approximately full.

REFLECTION.—The change of direction of a light ray when it meets a non-absorbing surface and is thrown back. See P. 572 Optic Projection.

REFRACTION.—See page 127.

REFRACTIVE INDEX.—When a ray of light passes obliquely from one medium into another of different density, the ratio between the lines of the angle of incidence and angle of refraction is known as the "index of refraction" of the second medium with respect to the first.

RELIEF PROJECTIONIST.—The projectionist who works a short shift to relieve the regular projectionist during meal times or for some other purpose.

REMOTE CONTROL.—The control of apparatus from a point some distance removed therefrom, as, for instance, a motor generator located in a basement may be started, stopped and controlled from the projection room.

RESIDUAL MAGNETISM.—As applies to a dynamo, the magnetism retained by its field magnet when the machine is not in operation.

RESISTANCE.—That property of an electrical conductor which opposes the flow of current. Also the term frequently applied to a rheostat.

RESISTANCE COIL.—A coil of resistance wire, such as is used in making up the resistance of a wire coil rheostat.

RESISTANCE LOSSES.—Losses due to the resistance the current encounters in opposition to its flow. See "Copper Loss."

RESISTANCE OF ARC.—The resistance offered by the floor of the positive crater in the arc stream and the tip of the negative carbon.

RESISTANCE WIRE.—Wire composed of special alloy designed to offer a fixed pre-determined resistance to current flow. It is used for various kinds of rheostats.

RETURN WIRE.—Same as "Negative," which see.

REVERSIBLE MOTOR.—An electric motor which may be run in either direction, as in street car work.

REWINDER.—A device for transferring film from one reel to another.

REWINDING.—The process of transferring film from one reel to another. This process is necessary each time a film is projected in order to change the beginning of the film from center to outside of film roll.

RHEOSTAT.—A device consisting of several units of resistance which are electrically coupled in such way that the current must pass through the entire length of each unit in order to reach the next. A rheostat may be adjustable, so that the current may be forced through the entire series of resistance units, or some of them be cut out, at the will of the man in charge, or it may be non-adjustable so that the current must pass through the entire series of coils or grids. The resistance of a rheostat may be made up of coils of resistance wire or banks of cast iron resistance grids.

RING OILING.—A method of oiling machinery bearings. A ring of considerably greater diameter than the shaft is hung upon it, the lower portion of the ring extending down into a reservoir of oil under the bearing, so that the ring being revolved by the shaft, oil is carried up by it to the bearing.

ROCKER ARM.—That part of a dynamo or motor to which the brush holders are attached, which may be rocked back and forth to shift the position of the brushes around the commutator to the point of least sparking.

ROTARY CONVERTER.—A dynamo for generating both direct and alternating current. Remembering that current generated in D. C. dynamo armatures is A. C., it will be seen that if the armature current be led to collector rings A. C. will be obtained. If the machine be run as a D. C. motor A. C. may be had at the collector rings, and if run as a synchronous A. C. motor, direct current may be obtained from the commutator. The rotary converter may also be defined as a rotary transformer.

ROTARY FIELD.—The field created by a combination of alternating currents differing in phase, so that if an armature of suitable winding be rotated therein the field will rotate because of induced currents. The action of an induction motor depends upon the creation of a rotary field.

ROTOR.—In a dynamo or motor, the part which revolves.

R. P. M.—Revolutions per minute.

R. P. S.—Revolutions per second.

RUBBER.—As applies to insulation, rubber may be used in different ways. In the form of a rather thin, plastic mass it may be placed on a wire and vulcanized. It is used for insulating tape, and as a vulcanite or an ebonite it is used for switch handles, insulating tubing, etc.

R. C.—Rubber Covered.

RUBBER COVERED WIRE.—See page 80.

SATURATION.—As applies to a magnet, the highest power to which the magnetic flux can be raised. The point at which the metal will receive no further magnetism.

SCREEN.—In projection, the surface to which the picture (image) is projected.

SCREEN, METALLIC SURFACE.—A screen surface consisting for the most part of metallic powder, such as aluminum. Tin foil has also been used with some success.

SCREEN, MIRROR.—A screen consisting of a plate glass mirror, the surface of which has been ground to break up the regular reflection.

SCREEN, SEMI-REFLECTING.—A term commonly used to describe metallic and other brilliant surface screens, which to greater or less extent give both diffuse and regular reflection.

SCREEN, DIFFUSING.—A screen which has high powers of diffusion of light.

SCREEN, CALSOMINED.—A backing of suitable material, usually plaster or cloth, which is coated with calsomine. See page 229.

SCREEN, PAINTED.—A backing of suitable material the surface of which is painted, either with a mixture of white lead and zinc, or white zinc, mixed flat. See page 227.

SCREEN BORDER.—A border of flat black or other dark color surrounding the picture, for which it serves as an outline. See page 240.

SCREEN BRILLIANCY.—The apparent brilliancy of the screen surface as viewed from the auditorium; also the degree of brilliancy per unit of area of the screen surface as shown by photometer measurements.

SCREEN SETTING.—The immediate surrounding of the screen.

SECONDARY COIL.—In a transformer, a coil of insulated wire in which the secondary current is induced. See "Primary Coil."

SECONDARY CURRENT.—The current induced in the secondary coil of a transformer. The current delivered to a projection lamp by an Economizer, Inductor or Compensarc.

SECONDARY E. M. F.—The voltage of the current induced in the secondary coil of a transformer.

SELF CONTAINED.—A term employed to describe a machine the essential parts of which are all contained in one frame, or in one foundation.

SELF OILING BEARINGS.—Machine bearings which are oiled automatically by the operation of the machine itself, the oil usually being contained in an oil well or reservoir located beneath the bearing, from which it is delivered to the bearing by suitable means. See "Ring Oiling."

SERIES.—As applies to electrical machines, lamps or devices, a connection in such way that the current must pass through two or more of them in successicn in its passage from positive to negative.

SERIES WOUND DYNAMO.—A dynamo in which the field magnets are wound with a few turns of heavy wire which is in series with the armature and the external circuit, so that the entire output of the armature must pass over the field coils.

SERIES-SHUNT WOUND DYNAMO.—A dynamo the field magnets of which carry both shunt coils and series winding.

SERIES-PARALLEL CONNECTION.—A circuit containing groups of current-using devices connected in parallel (multiple) with each other, the groups themselves being connected in series. A series multiple connection.

SERIES WOUND MOTOR.—A motor wound the same as a series wound dynamo, insofar as concerns its field coils.

SERVICE WIRES.—Wires leading into the consumer's premises from the street mains.

SHELLAC.—A resinous varnish the liquid component of which is alcohol. It is used as an insulator in certain classes of work. It may be thinned with wood or denatured alcohol.

SHORT CIRCUIT.—Commonly termed a "Short." In the common acceptance of the term a fault in an electric circuit or apparatus, usually due to defective insulation, by means of which the current follows a low resistance by-path to a conductor of opposite polarity, and either inflicts damage, or is wasted in so doing.

SHUNT.—In an electric circuit a branch conductor joining the main circuit at two points, forming a parallel path, so that the current is divided, a portion passing through the main circuit and a part through the branch.

SHUNT CIRCUIT.—Same as "Shunt," which see.

SHUNT COIL.—A coil joined in shunt to the main circuit, as the field magnet shunt coil of a dynamo or motor.

SHUNT WOUND DYNAMO.—A generator having its field coil connecting in shunt with the main circuit.

SHUNT WOUND MOTOR.—A motor having its field coil connected in shunt with the main armature circuit.

"SIDE" OF 3-WIRE CIRCUIT.—In a 3-wire system the neutral wire and one (either) outside wire forms one "side" of the system.

SINGLE POLE SWITCH.—A switch which controls only one of the wires of a circuit. A knife switch having only one blade.

SINGLE THROW SWITCH.—A knife switch which makes and breaks on one set of contacts only.

SOLID CARBONS.—Carbons having no "core." Carbons having a presumably uniform density throughout.

SPEED INDICATOR.—As applied to projection, a device designed to indicate the speed of projection on a direct reading dial.

SPHERICAL ABERRATION.—See page 129.

SPHERICAL CANDLE POWER.—The candle power of a light source measured in every direction.

SPLICING.—Joining two sections of a film or wire together.

SPLIT PHASE.—A single phase current divided into polyphase by means of a phase splitting device. See "Phase Splitter."

SPROCKET.—A revolving toothed roller or wheel by means of which movement of film through projector is caused and controlled.

SPLIT PHASE MOTOR.—A single phase induction motor provided with a phase splitting device for starting.

STANDARD CANDLE.—A sperm candle so made that it consumes 120 grains of wax an hour.

STANDARD FILM.—See page 130.

STAR.—As applies to projection, the member of a star and cam type of intermittent movement to which movement is imparted by the actuating cam. The part of an intermittent movement of the star and cam type which is attached to the intermittent sprocket shaft.

STEEL.—A compound of iron, about 3 per cent. of carbon and usually small quantities of silicon and manganese. It is the carbon which causes the metal to harden when cooled suddenly from red heat, and to soften again when cooled slowly.

STEP-DOWN TRANSFORMER.—A transformer which reduces the primary voltage and increases the amperage in proportion.

STEP-UP TRANSFORMER.—A transformer which delivers higher secondary voltage than the impressed primary voltage, decreasing the amperage in proportion.

STEREO.—Contraction of the word Stereopticon.

STEREOPTICON.—A light source and optical train, together with the necessary housing and mechanism for holding and adjusting the lenses, for the projection of still pictures (transparencies) to a screen.

STOPPING DOWN.—In projection, the act of reducing the diameter of the free opening of a lens.

STORAGE BATTERY.—A form of battery which, when subjected to the action of an electric current undergoes certain chemical changes, enabling it to produce electric power in proportion to the energy consumed in producing the change. It is erroneously called a "storage" battery. As a matter of fact there is no actual electricity in a "storage" battery, but instead there is an ability to produce or generate electricity.

STRANDED WIRE.—A wire composed of several smaller wires, usually twisted together.

STRANDED WIRE, ASBESTOS COVERED.—A conductor made up of a large number of very small wires (usually No. 30 or 31 B & S) in order to obtain flexibility, covered with asbestos insulation so that it may be used in places where the heat is too great to allow of the use of ordinary insulation.

STRIKING AN ARC.—The act of bringing the carbons of an arc lamp into contact and separating them again in order to obtain an electric arc.

A. S. W. G.—Abbreviation for American Standard Wire Gauge, commonly known as the "B and S" wire gauge.

SYNCHRONISM.—A relation as to time of the pressure waves of two or more alternating currents when combined in an electric distribution system. See Fig. 5.

SYNCHRONIZING.—So regulating the operation of two A. C. generators that they will be identical and simultaneous both in phase and frequency.

SYNCHRONOUS MOTOR.—An A. C. motor which must be brought up to speed and into step with the phase of the generator before being connected direct to the circuit. Such a motor is to all intents and purposes an ordinary A. C. generator run as a motor.

TAKEUP.—A device by means of which the film is wound upon a reel as fast as it comes from the projector mechanism.

TAKEUP PULL.—The pull exerted by the takeup tension. It must not exceed 15 ounces at the periphery of a 10-inch reel, or 16 ounces on an 11-inch reel.

TAKEUP TENSION.—See "b" under "Tension."

TAPED JOINT.—A wire joint or splice, wrapped with insulating tape.

TAPE, INSULATING.—See "Insulating Tape."

TENSION.—As applied to projection (a) the pressure exerted by the tension springs, either through the tension shoes or direct, upon the film at the aperture. (b) The tension exerted by a spring upon two friction discs for the purpose of revolving the film reel in the lower magazine, providing slippage so that the reel, although driven by a power having steady speed, may revolve at differential speed, gradually slowing up as the film roll increases in size.

TENSION SHOES.—Metal bars upon which the tension springs bear which themselves bear directly on the film and provide braking friction to stop film over aperture.

TENSION SPRINGS.—The springs which provide braking action to stop the film over the aperture at the completion of the intermittent movement.

THREE-PHASE.—See page 18.

THREE-WIRE CIRCUIT.—A circuit in which all three wires of a three-wire system are used.

THROW.—See "Projection Distance."

THREE-WIRE SYSTEM.—See page 85.

THUMB MARK.—A mark on the lower left hand corner of a stereo slide when the slide is held so as to be read against the light. Thumb mark is on the face (cover glass) side of the slide.

TORQUE.—The pulling force which tends to rotate, as the rotating of a motor armature.

TRAILER.—A short length of opaque film attached to the end of a reel of film so that projection may proceed up to the end of the film proper without showing white light upon the screen.

TRANSFORMER.—A device for transforming A. C. of high voltage to a lower voltage and increased amperage, or vice versa. See page 544.

TRAVELING ARC.—An unsteady arc, particularly one in which the point of highest illumination in the crater moves about, usually due to faulty carbons.

TRIPLE POLE, SINGLE THROW (T. P. S. T.) SWITCH.—A knife switch with three blades, but which makes and breaks on one set of contacts only.

TWO-PHASE CURRENT.—See page 18.

TWO-PHASE MOTOR.—An induction motor which, instead of having a single field winding, has two separate windings, each taking current from a single phase circuit of the same frequency, but differing in phase by one-quarter of a period. A motor made to operate on two-phase lines.

TWO-PHASE SYSTEM.—A system supplied with two alternating currents of the same frequency, but differing in phase by a quarter of a period. It may be supplied by two separate two-wire circuits, or by a three-wire system in which one wire is common to the two currents.

TWO-WIRE SYSTEM.—A system in which only two wires are employed.

ULTRA VIOLET RAYS.—Rays of light existing beyond the violet light of the visible spectrum. These rays have a vibration in excess of eight hundred billion per second.

UNBALANCED LOAD.—As applies to the 3-wire system, a condition in which more current is consumed on one side of the system than on the other, which has the effect of compelling one generator to carry a heavier load than the other.

UNDERWRITERS' RULES.—See "National Electric Code."

USEFUL LIFE.—A term applied to many things, but in electrics particularly to incandescent lamps, which deteriorate with age. It is the time an incandescent lamp will burn before its output of light has decreased more than 20 per cent. When a lamp has fallen below 80 per cent. of its rated c. p. it is the part of true economy to replace it with a new one.

VOLATILIZATION.—In projection, the transforming of carbon into vapor through heat.

VOLT.—Unit of electrical pressure. See page 50.

VOLTAGE DROP.—The drop in voltage due to the resistance of the conductors. Voltage drop exists in every circuit. See "Copper Loss."

VOLT-AMMETER.—An instrument for measuring current consumption in watts.

VOLTMETER.—An instrument of high resistance for measuring electrical pressure.

WATER GLASS.—Soluble glass. Used as a binder for carbon cores. It is the residue of water glass which forms the white, light weight ash with which the interior of the lamphouse becomes coated.

WATT.—The practical unit of electrical power. See page 53.

WATT HOUR.—The energy consumed when one watt of electrical energy has been used for one hour.

WATT-HOUR METER.—A meter used for measuring electrical consumption in watt hours.

WATTS PER CANDLE POWER.—The specific consumption of an electric lamp is its watt consumption per mean spherical candle power. In connection with incandescent lamps, the term "watts per candle power" is used commercially to denote the watts consumed per mean horizontal c. p.

WESTERN UNION WIRE JOINT.—See figure 26.

WIRE GAUGE.—A gauge for measuring round wires according to an arbitrary standard. See page 78.

WORKING APERTURE.—In projection, that portion of the aperture of a lens which is actually in use in the sense that it is contributing to the improvement of the finished screen result.

WORKING DISTANCE.—The distance from film to first surface of a projection lens when it is adjusted to actual working conditions. See "Back Focus."

AN EMPLOYEE IS PAID FOR THREE THINGS, VIZ: TIME, STRENGTH AND KNOWLEDGE. THE FOOL CAN GIVE THE FIRST, THE DULLEST OF WIT MAY GIVE THE FIRST TWO, BUT IT IS THE WORTH-WHILE MAN OF INTELLIGENCE AND BRAINS WHO CAN SUPPLY THE THIRD AND WHO GETS THE REAL MONEY AND THE BIG POSITION WHEN IT COMES.

Electrical Terms and Their Meaning

THERE are a few electrical terms with which the projectionist comes into quite intimate contact in his daily work. It is essential that he have a thorough understanding of what they actually represent to the end that he be able to use them intelligently in the various calculations arising from time to time in his work.

POLARITY.—Polarity and Potential mean the same thing. When wires are attached to opposite terminals of the same dynamo there is present in these wires an electrical condition which enables them to perform work. Properly connect them to an electric motor and the energy in or on these wires will cause its armature to rotate and exert a pull and thus produce power.

Attached to a lamp the energy in or on these wires will cause the filament or the carbons thereof to become white hot, and thus produce light.

This electrical condition is termed "polarity" or "potential." It is, or it represents the electrical affinity which the positive wire of an electric circuit has for the negative wire of the same circuit, or the negative wire of any circuit attached to the same dynamo. It represents the inclination of the electric impulse to "flow" from positive to negative, which same is termed "current flow." See Page 3.

POSITIVE AND NEGATIVE AS APPLIES TO D. C.—When wires are charged with direct current one wire is continuously positive and the other negative.

POSITIVE AND NEGATIVE AS APPLIES TO A. C.—When wires are charged with alternating current each wire of the circuit is alternately positive and negative many times every second. If it be 60 cycle current, then each wire is positive 60 times and each wire negative 60 times per second.

VOLTAGE OR ELECTRO MOTIVE FORCE (E. M. F.).—Electric current is usually treated as having both pressure and volume. In its action as relates to these attributes, as well as regards the item of friction, electricity is very similar to, and may be compared with water, but it must be remembered that the similarity exists in similarity of action only.

Water may be subject to physical examination. We can feel it, watch its action and weigh it. On the other hand, electricity is an absolutely impalpable substance—if we may even call it a substance. It apparently is without weight. We cannot see it, except in the form of light, which is not the current itself but a product of its action. We cannot feel it, except in the form of a "shock" occasioned by the current passing through the tissues of the body.

Voltage corresponds in effect, or in its action, to the pressure of water in a pipe, or to the pressure of steam in a boiler. A dry battery, such as is used for electric bells, has a pressure of approximately one volt. It imparts that pressure to wires connected to its terminals, so that if you attach two wires to such a battery, they will, at any portion of their length, have an electrical pressure of one volt. If you connect the zinc of a second battery with the carbon of the first battery by means of a short piece of wire, and then attach two other wires to the two remaining binding posts, you will have what is known as "series" connection, and a resultant pressure of two volts between the two last named wires. A third battery connected in series would raise the pressure to three volts, and so on indefinitely.

Instead of using batteries for producing light and power, which would be entirely impractical, we use a machine called a dynamo, each one of which is designed and built to produce a certain voltage, which may be anywhere from one to 500 volts D. C., or from one to 6,000 volts A. C.

Remember that voltage corresponds to pressure, and is similar in its action to pressure in a steam boiler, but that voltage acts only between the positive and negative wires of the dynamo or battery which generated it, and that the positive attached to one generator has no affinity or attraction to or for the negative attached to another dynamo, or for the ground, except as it offers a path to the negative of the generator to which the positive is attached. Get this fact firmly fixed in your mind. Ninety-nine out of every hundred non-electricians believe current generated by a dynamo seeks to escape into the ground. This is not so, except insofar as the ground may offer a path of electrical conductivity between two wires of opposite polarity. See page 6.

AMPERE is the term used to denote quantity. It represents the volume of current flowing through, or along a wire, just as gallons or barrels represent the quantity of water flowing through a pipe, or cubic inches the volume of steam flowing. As a matter of fact we do not actually know that anything flows in or along the wire of an electric circuit. Eminent theoretical electricians say there is an actual flow; other equally eminent theoretical electricians say there is not, but that what we consider as current flow is really a "molecular bombardment." With these highly technical questions, however, we have no concern. For our purpose it is sufficient to say that the current flows along the wires, exactly as water flows through a pipe.

HOW WORK IS ACCOMPLISHED.—The work performed is accomplished by voltage, or pressure, working through amperage, or volume. When a water wheel is turned by water it is not the water but the pressure which is consumed. True, the work is sometimes done by falling water, in which case the weight of the water amounts to and is the same as pressure, and in that case it is the pressure produced by gravity or weight which does the work. It, therefore, follows that the higher the pressure or voltage the greater the amount of work a given current volume or number of amperes can accomplish.

For instance, if we supply an engine with steam at fifty pounds pressure, there will be a certain, definite number of cubic inches of steam used at each stroke of the piston, and a certain definite number of foot-pounds of work will be accomplished. But if, without changing anything else, we raise the steam pressure to one hundred pounds, the engine, while still using precisely the same number of cubic inches of steam at each stroke of the piston, will perform twice as many foot-pounds of work. In this case, while the volume of steam used remains unaltered, the pressure is doubled, in both cases the pressure is entirely consumed, but the volume of steam remains and is not consumed. The same power would be produced by the lower pressure if the area of the piston be doubled, since twice as much pressure would be made available through increase of volume; but again it would be pressure, not volume, which would be consumed.

It is the same with electric current. Ten amperes of current at 50 volts represents a certain, definite amount of energy. Ten amperes at 100 volts represents just twice as much, though it is also true that twenty amperes at 50 volts would amount to the same thing in power production. The point we seek to make is that amperage or volume is merely the vehicle through which pressure or E. M. F. works, and that in the production of power in any form it is voltage (pressure) and not amperage (volume) which is consumed.

In a steam engine, with the steam at given pressure we may increase the power of the engine by either increasing the area of the piston or the length of its strokes or by increasing the pressure of the steam. In a water motor we may increase the capacity to do work either by increasing the size of the motor or the pressure of the water. The same thing holds true with electricity. We may increase its capacity to do work either by increasing the volume of current (amperage) or by increasing the voltage. To perform a given amount of work with a low pressure (voltage) a large volume (amperage) is necessary, but if the voltage be high the same amount of work can be performed with much less volume of current. The horse power of work performed by electric current is represented by the voltage times the amperes divided by 746.H.P. = Volts × Amperes ÷ 746.

OHM.—In passing through a pipe water encounters resistance by reason of the rough sides of the pipe, as well as by reason of the internal resistance of the water itself. This resistance tends to retard the flow. Precisely the same is true with electricity. In passing through a wire electric current encounters resistance, and this resistance tends to retard the flow of current. It is measured in ohms, the definition of which is given on page 35.

The effect of resistance is to produce heat. In other words power consumed in overcoming resistance is transformed into heat. In a water pipe the resistance increases as the volume of water passing through a pipe of given diameter is increased, or as the diameter of the pipe is made smaller with relation to the volume of water flowing. The same thing is true of current. Having a wire of given diameter its resistance increases as the current flow becomes greater, and decreases as the current flow becomes less, or, having a given current flow, the resistance decreases as the diameter of the wire is made greater, or its length is decreased.

WATT.—Watt is the unit used to measure the amount of electrical energy expended—the amount of work actually performed. It is found by mutiplying the voltage by the number of amperes, and is transformed into horsepower by dividing that result by 746, since 746 watts is equal to one electrical horsepower. For example: If we have 10 amperes at 110 volts the amount of energy expended would be equal to 110 ×

10 = 1100 watts, which, divided by 746, equals 1.47 h. p. If, on the other hand, we use 110 amperes at 10 volts, the result in power would be the same. But if we use 10 amperes at 10,000 volts we then would have 10,000 × 10 = 100,000 watts, which, divided by 746 equals 134 h. p.

USE OF ELECTRICAL TERMS IN CALCULATIONS.—In projection rooms not equipped with a reliable voltmeter and ammeter it will be difficult for the projectionist to make intelligent calculations, since in order to find a desired quantity, be it voltage, amperes or ohms, he must know the value of the other two. In order to accurately calculate the number of amperes flowing in a circuit it is necessary to know exactly the number of ohms resistance the circuit offers (including wires, appliances, etc.) and the exact voltage.

It is, however, highly desirable that the projectionist understand how to make electrical calculations, at least insofar as applies to his projection circuit, since under some circumstances such knowledge will be necessary to intelligent work.

The projectionist must firmly fix in his mind the fact that where the projection circuit is concerned the resistance does not lie wholly in the rheostat, or whatever takes its place. The wires, carbon-arms and carbons usually offer comparatively slight resistance, but a very considerable portion of the total resistance of a projection circuit is in the arc itself. Under usual conditions the resistance of the wires, carbon-arms and carbons may, for the purposes of calculation, be neglected, but unless the resistance of the arc itself be taken into consideration, very serious error will result.

When making electrical calculations it is customary, for the sake of brevity, to use the letters E, C, and R, in which E stands for "electromotive force," which is merely another name for voltage; hence E stands for voltage; C stands for current flow, meaning amperes; hence C stands for amperes; R stands for resistance in ohms; hence R stands for ohms.

The projectionist should also remember that in a common fraction the horizontal line always means "divided by," thus 1/2 really means 1 ÷ 2. To divide 1 by 2 we put down the 1, followed by a period, called a "decimal point" and then add ciphers thus: 1.00. We now have 1.00, with a decimal point between the one and the two O's. In dividing 1 by 2 we only need one cipher, thus 1.0 and 1.0 ÷ 2 = .5, which is exactly the same thing as 5/10, or 1/2. The rule is to count the figures or ciphers to the right of the decimal point in the number being divided, and then, beginning at the last figure of the result, count an equal number, and place the decimal to the left of the last figure counted. If there are not enough figures in the result to do this, add enough ciphers on the left.

When dealing with formulas, E/C means that the quantity represented by E is to be divided by the quantity represented by C, E being the voltage and C amperes. If there be two or more quantities above or below the line, with no sign between them, it means that they are to be multiplied together, thus: $\frac{E}{CR}$ means that E (volts) is to be divided by C (amperes) multiplied by R (ohms). $\frac{E-15}{C}$ means that after 15 has been subtracted from the quantity represented by E (volts), the remainder is to be divided by the quantity represented by C (amperes). The student will be greatly benefited if he will practice writing out formulas of this kind in letters, afterward substituting quantities in figures and working them out.

Ohms law sets forth the fact that the number of amperes flowing is equal to the voltage divided by the resistance in ohms. We therefore have $\frac{E}{R} = C$, or in other words, volts divided by ohms equals amperes. It then follows that if $\frac{E}{R} = C$, C multiplied by R must equal E. It also follows that $\frac{E}{C} = R$. It works out as follows: We know that the ordinary 110 volt, 16 c. p., carbon filament incandescent lamp requires approximately one-half ampere of current to bring it up to candle power. What is its resistance? Using the formula $\frac{E}{C} = R$, substituting figures, we have $\frac{\text{110 volts}}{\text{.5 of an ampere}} = 220$, the number of ohms resistance in the filament of the lamp. Again applying the formula $\frac{E}{R} = C$, we have $\frac{110}{220} = .5$, or ½, as the amperage 110 volts will force through 220 ohms resistance. All this seems simple enough of understanding and application, but to make it yet more plain we will consider the formula $\frac{E}{C} = R$, which means voltage divided by amperes equals ohms. If the voltage be 50 and the amperes 10, then E would be 50, C would be 10, and R would be $50 \div 10 = 5$. If the voltage were 110 and the amperage 5, then E would be 110, C would be 5, and R would be $110 \div 5 = 22$ ohms.

When, however, we come to consider the projection arc circuit a new element enters in the shape of the resistance of the arc itself, and if we propose to be absolutely accurate we must consider also the resistance of the carbon arms, wires, etc. That degree of refinement, however, is seldom, if ever, necessary in a projection circuit calculation.

In leaping the gap between the carbon tips of the arc lamp the current encounters high resistance. In overcoming resistance voltage is consumed, as will be more thoroughly set forth and explained under "The Light Source." In other words, when current flow is opposed by resistance, and that resistance is overcome, there is a consequent drop in pressure or voltage; pressure having been consumed in the process.

For reasons not necessary to enter into at this time, the D. C. arc, for a given amperage, is longer than the A. C. arc. It therefore follows that its resistance will be higher. The accepted theory is that all voltage is consumed at the arc. Whether or not this is true is a highly technical question, which it would be unprofitable to discuss in this book.

We shall accept the theory as stated. It then follows that the rheostat, or whatever takes its place, must reduce the voltage to just that pressure which the resistance of the arc will consume when the arc is burning normally.

ARC VOLTAGE CONSTANTS.—Under varying conditions projection arcs will operate at their best at different voltage drop. Tables on page 395 and 400 are as reliable as any though various carbon combinations would undoubtedly alter the results as set forth therein in considerable degree.

The figures in tables 21 and 22 are NOT given as an accurate, unvarying factor. They are designed as a fairly accurate guide only. They may be safely used in figuring necessary resistance for a temporary set-up.

And now let us illustrate the method of applying this knowledge in practice.

Taking a 60 ampere arc, for example, what is its resistance? Accepting for the sake of simplicity in figuring the constant 60 volts as approximately correct for a 60 ampere arc, we then have $\frac{E}{C} = R$. Substituting figures we then have $\frac{60}{60} = R$, and $60 \div 60 = 1$ ohm, which is the arc resistance, or the resistance necessary to consume 60 volts.

Let us prove this. Suppose the line voltage to be 110. The total resistance necessary to allow 60 amperes to pass must then equal $\frac{E}{C} = R$ the voltage divided by amperage; hence amperes being 60 and voltage 110, the resistance will be $110 \div 60 = 1.833$ ohms. We have already seen that the resistance of the arc is 1 when the arc voltage is 60. Subtracting the arc voltage from the line voltage (110—60) gives 50 as the drop in voltage there must be across the rheostat. In other words, there must be 50 volts of electric energy consumed, or "used up" in the rheostat, which will appear in the form of heat.

Again applying the formula $\frac{E}{C} = R$, we have $50 \div 60 =$ .833+ (the + sign meaning that the division could be carried further) as the ohmic resistance of the rheostat. If we now add the resistance of the arc and the rheostat together (1 plus .833) we shall have as a result 1.833, which corresponds to the total resistance necessary to allow 60 amperes to pass, the slight discrepancy as between 1.832 and 1.833 being due to the division being only carried to the fourth decimal point.

If the amperage were more than 60, line voltage remaining the same, then the total resistance would be less, since voltage divided by amperes ($E \div C = R$) equals resistance, and the result obtained by dividing 110 by a number greater than 60 is a less number of ohms. Conversely, if the amperage be less than 60 the total resistance necessary (arc and rheostat) would be greater.

The higher the line voltage the greater must be the resistance to accomplish a given current flow, as will be seen by applying the formula $\frac{E}{C} = R$.

FORMULA TO USE IN FIGURING ARC VOLTAGE.—In practice we amend the before named formula for general calculations in such a way as to automatically take care of voltage drop, thus: Suppose we wish to calculate the necessary ohmic resistance of a rheostat to pass 60 amperes D. C. from 110 volt lines. Instead of using the $\frac{E}{C} = R$, we amend it thus: $\frac{E-55}{C} = R$, the "55" being the constant for voltage drop of a 60 ampere D. C. arc. Substituting figures we would then have $\frac{110-55}{60} = .9166$ ohms, and we thus at one operation have the result sought. In using this latter formula we would, of course, use the voltage drop constant for the amperage used in each case.

A. C. VOLTAGE DROP.—When figuring A. C. projection arc voltage drop we must use a different constant, considerably lower in value. See page 400.

As an example of the possible actual practical value of knowledge, such as is contained in the immediate foregoing, suppose you are called upon to take charge of projection in a theatre employing a private 125 volt light plant, using 50 amperes at the arc. You find the rheostats in bad shape and order new ones. Instead of ordering a 50 ampere, 110 volt rheostat you, discarding unintelligent guess-work, apply the formula $\frac{E-50}{C} = R$, or, better still, measure the actual voltage of the arc by disconnecting the voltmeter and touching one of the wire attached to its terminals to each carbon of the projection lamp, when you have the arc burning normal. Suppose the voltmeter reads 52. You would then have the formula $\frac{125-52}{50} = 1.46$ ohms as the necessary resistance of a rheostat to deliver exactly 50 amperes, under the conditions at your plant. Would you not rather be able to hand the manager an order for exactly what you want, and need, than an order which will probably result in your need being only met approximately?

RULE O' THUMB.—There is a very simple formula, easy of application, which combines the three formulas into one. It is called the "Rule of Thumb." It is expressed for general use as: $\frac{E}{CR}$

To use the formula you have but to cover the symbol or letter representing the quantity desired, and what remains will produce the answer, thus: Suppose we wish to ascertain the resistance in ohms. We cover up the "R" in the formula and find that we have $\frac{E}{C}$ remaining, which will give R, the desired quantity. In using this formula on projection circuits the top letter must be expressed as E minus the arc voltage, the same as in the regular formulas.

THE UNION MAY BE ABLE TO RAISE YOUR WAGES—YES, BUT IF YOU ARE REALLY WORTH MORE MONEY IT WILL BE VERY MUCH EASIER FOR IT TO DO SO.

Resistance

THE one thing which enters into all problems of the electrician and the projectionist is resistance. It is met with in every phase of electrical work and so far as the production of light be concerned, it is the very keystone of the structure.

When an electrical impulse passes through or over a wire it encounters resistance, which in its action is very similar to the resistance encountered by water in flowing through a pipe.

When water flows through a pipe it encounters resistance which will be directly in proportion to the diameter and the length of the pipe, the roughness or smoothness of its interior surface, and the quantity of water flowing per minute. To some slight extent this resistance is the result of molecular friction within the water itself, but for the most part the friction is between the water and the walls or sides of the pipe.

In a pipe of given diameter the resistance will increase with (1) increase of flow or volume of water, (2) increase of the length of the pipe and (3) with increase in roughness of the interior walls of the pipe.

Conversely, resistance will decrease as the flow of water is diminished, the length of the pipe decreased or with increasing smoothness of the walls of the pipe.

With a given flow of water, resistance will increase as the length of the pipe is increased, as the diameter of the pipe is made smaller or as the roughness of the walls of the pipe increases, or resistance decreases as the pipe diameter is increased, the pipe made shorter or as its walls become more smooth.

Pressure is the motive power, either in the case of water or electricity, and resistance always consumes pressure, and consumes it precisely in proportion to the amount of resistance encountered. In the third edition of the handbook we explained this proposition by means of a diagram which we do not believe can be materially improved upon, hence it is herewith reproduced as Fig. 6.

In Fig. 6 we see a large water main, upon the top of which is mounted a gauge registering 100 pounds pressure. To this main, pipes A B and C are connected. Pipes A and B have a half inch interior diameter. Pipe B is short, having a length, let us assume, of one foot. The water from it spurts out under high pressure, carrying itself almost horizontally over a considerable distance. Pipe A we will assume to have a length of 100 feet (in a drawing of this kind it is impossible to draw the pipe lengths in correct proportion and still make the details large enough to be understandable, therefore we assume pipe B to have a length of one foot and pipe A 100 feet, that being about the proportions that would give something approaching the results shown). You will

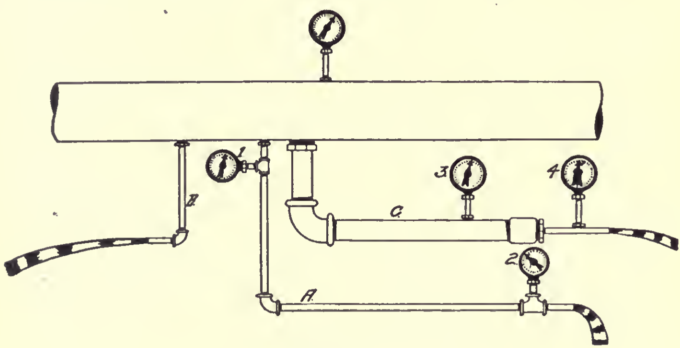


Figure 6.

observe two things with relation to pipe A: First, that whereas gauge 1 registers almost the same pressure as the gauge on the large main, gauge 2 registers very much less, and the water from pipe A spurts out with but little force. The reason for this is as follows: Pipe B is short, and whereas the water encounters high resistance because of being forced through with great rapidity, still there is not much length to the pipe, hence comparatively little of the total pressure is consumed in forcing the water through pipe B, even at high speed. Therefore it spurts out at the end of the pipe with great force. Pipe A, on the other hand, is 100 feet long, and the water in flowing through that length of half inch pipe would, at the same rate of flow, encounter 100 times the resistance offered by pipe B. Of course, the actual resistance encountered is not 100 times as great, because as pressure is consumed in overcoming the resistance of the long pipe the movement of the water is slowed down. In this we see the exemplification of the effect of added resistance due to increased length of pipe, diameter remaining the same.

Now let us consider pipe C, which we will assume to have a total length of 10 feet of three inch, and two feet of half inch pipe. We observe that gauge 3 on pipe C registers essentially the same as does the gauge on the water main. This is because, since only the capacity of the half inch pipe at its end can flow, the water in pipe C is moving slowly, hence encounters very little resistance. In other words, pipe C is working far below its normal capacity. The short pipe at its end, however, is working far above its normal capacity, but it is short, hence the resistance it offers is comparatively slight, and gauge 4 registers but little less than gauge 3 and the water-main gauge.

We could go on at great length, showing the action of resistance as applied to water, but we think enough has been said to make the meaning clear.

The pressure under which the water might be would not affect the result, except that the higher the pressure the greater the amount of resistance which can be overcome, and vice versa.

A pipe of given diameter will carry water up to its capacity under any pressure sufficient to move the liquid and less than that sufficient to burst the pipe. A pipe of given diameter will, however, only convey a certain number of gallons of water per minute without excessive friction, regardless of whether the pressure be ten pounds or fifty pounds per square inch.

When the point is reached where resistance to flow becomes excessive, the normal capactiy of the pipe is said to have been reached.

It is quite true that we may still force a greatly increased volume of water through the pipe, but it can only be done at the expense of largely increased power consumption. It is a costly proceeding to force a water pipe above its normal capacity, and the cost increases very rapidly as excess over capacity is increased.

Where it is necessary to convey a certain volume of water per minute, and the pipes are overloaded, the practical method of reducing the resistance attendant upon overload is to increase the diameter of the pipe until the desired flow is obtained with only normal friction loss. We therefore deduce the rule that

Increasing the diameter decreases the friction or resistance offered to a given flow, since the water is thus caused to move more slowly.

Another equation enters the matter, however, viz., the length of the pipe. Since resistance results largely from friction with the walls of the pipe, it follows that the longer the pipe the more friction there will be. We have already seen that with a given volume of water flowing, as the diameter of the pipe is decreased the friction or resistance is increased, and conversely, as the diameter of the pipe is increased the friction or resistance is decreased.

It is very evident also that with a given flow:

As the length of the pipe is increased the friction or resistance is increased. Conversely, as the length of the pipe is decreased the resistance becomes less.

We may therefore increase the resistance by (1) increasing the flow of water, (2) decreasing the diameter of the pipe, (3) increasing the length of the pipe, (4) increasing the interior roughness.

We may decrease the resistance by (1) decreasing the flow, (2) increasing the pipe diameter, (3) decreasing the length of the pipe, (4) making the interior pipe walls more smooth.

We believe the foregoing is simple enough to be readily understood.

What has been said of the action of water flowing through pipes is also true with relation to current flowing through or over wires.

If you substitute circuits of wire for the water main, and for pipes A, B and C, with volt meters in place of pressure gauges, and with lamps, motors or rheostats instead of the open pipe ends, you will get precisely the same relative result in loss of pressure (voltage) when current flow is sent through the circuits.

In considering electrical action the student should clearly fix in mind the proposition that the voltage or pressure of the current has absolutely nothing whatever to do with the size of wire necessary to convey the current. We may convey current at ten thousand or at fifty thousand volts on a number 40 wire, which is no larger than a very fine silk thread, but the amount of current (amperage) we could convey on such a wire would be very small indeed.

In passing through wires electric current encounters resistance, exactly the same as does water in passing through a pipe. A wire of given composition and diameter will convey a certain number of amperes without excessive resistance (electrical friction) precisely the same as a water pipe of given diameter and wall roughness will convey a certain given number of gallons without undue friction or resistance, and the point where resistance in the wire begins to rise above normal marks the "capacity" of the wire, exactly as it does in the case of the water pipe. Beyond that point the friction or resistance becomes excessive, manifesting itself in loss of pressure or voltage, which same is dissipated in the form of heat. This loss in pressure has been consumed in forcing the current against the resistance of the wire, precisely as was the case in the water pipe. It therefore follows that:

Loading wires beyond their normal capacity is expensive, and should be avoided for that reason if for no other, since the waste is registered on the meter and you will have to pay for it exactly the same as you pay for current used in the lamps or motors.

The loss in electric energy, however, is not the end of the matter, because if you attempt to force a wire in the excess of its rated capacity as shown by the underwriter's table (see page 70), heat in excess of normal temperature will be developed, and if the matter be carried too far (which can only be done by overfusing) the wires may get red, or even white hot, finally melting and stopping all current flow, and perhaps setting fire to the building in the process. Overloading wires is, therefore, not only expensive, but it is also dangerous.

Precisely as was the case with the water pipe, with a given current flow the resistance of a wire is decreased as the diameter of the wire is increased, its length made less, or its composition changed to one of greater conductivity and is increased as the diameter of the wire is made smaller or its length increased, or its composition changed to one of lower conductivity.

Resistance increases....With increased length of wire; or
As diameter is decreased; or
As the temperature is increased above normal; or
As the composition of the wire is

changed to an alloy having lower conductivity.

Resistance decreases....As length of wire is decreased; or
As the diameter is increased.
As the temperature is reduced, if it be above normal.
As the composition of the wire is changed to an alloy having higher conductivity.

NOTE.—The difference in conductivity of different metals makes the analogy of water and current action more complete, since it corresponds to roughness or smoothness of walls of the water pipe.

Different metals offer varying resistance to electric current as follows, taking the resistance of pure silver and pure copper as 1.

Copper	1	*18% Nickel Silver	19
Silver	1	Manganin	24
Aluminum	1.5	*30% Nickel Silver	28
Platinum	6	*Advance Wire	28
Norway Steel	7	*Climax Wire	50
Soft Steel	8	*Nichrome	66
*Ferro Nickel	17		

NOTE.—The Driver-Harris Company, manufacturers of resistance wires, are authority for these figures. We know of no more reliable source for information of this kind. Star (*) indicates Driver-Harris products.

In the foregoing table the figures refer to the amount of resistance each metal has, as compared to that of pure, annealed copper. For instance, platinum has 6 and climax wire 50 times the resistance of pure, annealed copper.

We have selected for a part of this table metals and compositions in very general use for resistance purposes. It will, of course, be understood that the figures given in the tables are based on metals and alloys of a certain standard purity, but inasmuch as the degree of purity will, in the very nature of things vary, the relative resistance will vary accordingly, though the variation should not be very great.

RESISTANCE AND TEMPERATURES.—In the case of all metals used for electrical work resistance increases as temperature increases. This holds true so far as concerns any and everything used for the purpose of conducting the electric current, except carbon. In the case of carbon the rule is reversed and resistance decreases with increase in temperature. This is true to such an extent that the carbon filament of an incandescent lamp offers about twice the resistance when cold that it does when the lamp is burning at normal capacity.

It might also be remarked that as a general proposition the resistance of liquids and of insulating materials becomes less as their temperature is increased.

TEMPERATURE CO-EFFICIENT.—The resistance of metallic conductors not being constant at all temperatures, but increasing with rise of temperature, and vice versa, it becomes necessary that the student understand the law governing this matter.

The increase or decrease of resistance of metals to electric current is directly proportional to increase or decrease of temperature.

NORMAL TEMPERATURE.—In figuring such matters all calculations are based on normal temperature, which is 75 degrees Fahrenheit or 24 degrees Centigrade.

The factor which enables us to calculate the resistance of metals with relation to temperature is termed the "temperature co-efficient." In all properly constructed tables of resistance wire the resistance per mil foot of the material is given at normal temperature, and the resistance at this standard temperature forms the basis of calculation of increased or decreased resistance by reason of temperature change. The figure given for temperature co-efficient is the fraction of an ohm change in resistance for each degree of change change in temperature. This co-efficient must be multiplied by the number of degrees of temperature change from the normal and the result added to or subtracted from the resistance at normal temperature, according to whether the material increases in resistance with heat, as in the case of metal, or decreases with heat as in the case of carbon, liquids or insulating material.

For example, let us assume the temperature co-efficient of a material to be .001, and that its resistance at normal (75 degrees F.) is 10 ohms per mil foot. What will be its resistance per mil foot at 175 degrees? Subtracting 75 (normal temperature in degrees) from 175 (working temperature) we find the difference to be 100 degrees, and since resistance increases .001 of an ohm for each degree of increased temperature, for 100 degrees increase of temperature the increase of resistance would be $.001 \times 100 = .1$ of an ohm. We now multiply the resistance at normal (10 ohms) by the fractional increase .1, which gives us the actual total increase of $10 \times .1$

= 1 ohm, so that the resistance of 175 degrees F. will be 10 ohms + 1 ohm = 11 ohms.

It is not our intent or purpose to do anything more than show the projectionist how the temperature co-efficient operates. It is not likely he will have occasion to actually use it in practice, but it is nevertheless necessary that he understand the principles upon which such things operate. Those who desire further information along these lines can secure from their public library books treating on resistance materials.

PROPERTIES OF CONDUCTORS.—Ordinarily electric conductors are selected with one of two ends in view. In one case low resistance, tensile strength, ductility and cost are the ruling factors. In the other case a comparatively high and non-fluctuating resistance is the important item.

In the first instance conductors for current distribution is what is wanted, and it is by reason of the fact that copper more nearly combines the four above named important factors than does any other metal that it has been selected as the standard electrical conductor.

In the second instance, a material to offer resistance is the thing desired, rheostatic resistance forming an integral part of electric circuits under some conditions.

PROPERTIES OF RESISTANCE METALS.—The materials now most generally used for rheostatic resistance in projection arc circuits are either cast iron, made up in grid form, or some one of the nickel steel resistance wires. It is very difficult, not to say impossible, to secure reliable data concerning the properties of cast iron, but it nevertheless forms an excellent and cheap resistance medium where the temperature co-efficient may be subject to some variation, and where a large difference between resistance at normal and resistance at high temperature is not of great importance. The resistance per mil foot is 64,3 ohms at normal. Climax resistance wire made by the Driver Harris Company, Harrison, New Jersey, has a resistance per mil foot of 500 ohms at normal. Its temperature co-efficient is .000543. Climax wire is a nickel steel alloy and a most excellent material for rheostat coils.

Eighteen per cent nickel silver is a composition containing 18 per cent of nickel. Its resistance varies somewhat with different lots. Its mil-foot resistance runs from 170 to 180 at normal. Its temperature co-efficient is .00015 per degree F. Ferro nickel has a mil-foot resistance of 170 ohms at normal; temperature co-efficient .00115 per degree F. Nichrome, also a Driver Harris product, is a practically non-corrosive alloy having a melting temperature of about two thousand six hundred degrees F. Nichrome is designed for use where high temperatures are the rule, as in heating coils, etc. Its mil-foot resistance is 660 ohms, and its temperature co-efficient point .000095 per degree F.

Advance wire, a Driver Harris product, is a copper-nickel alloy containing no zinc. It is claimed to be constant in its resistance under all conditions of service, hence it has no temperature co-efficient. Its mil-foot resistance is 294 ohms. It is particularly recommended for electrical installations where resistance is subjected to repeated heating and cooling.

We are indebted for the figures contained in the foregoing to the Driver Harris Company, than whom we know of no better authority from which to secure reliable data concerning resistance materials. Our intention in dealing with this matter has been merely to give our readers some understanding of how temperature affects resistance, and how the resistance of a material may be calculated with accuracy for any temperature, providing its temperature co-efficient and its resistance at normal be known; also to advise projectionists and theatre managers of at least one source from whence reliable resistance materials may be had in case of emergncy, and the names and peculiar qualities of the various metals obtainable from this source.

LOSS THROUGH RESISTANCE.—It is essential to intelligent, efficient work that the projectionist be able to figure the resistance of copper circuits. One of the very first duties of the up-to-date, progressive projectionist upon assuming charge of a projection room would be to determine whether or not the projection room circuits, including its feed wires are of sufficient size to operate efficiently and economically.

As has already been pointed out, the overcoming of resistance consumes voltage, and since all wires offer resistance to current flow, voltage will be consumed in (a) proportion to the size of the wire, (b) the length of the wire, (c) the temperature of the wire, (d) the composition of the wire, all these various factors interlocking with one another.

Up to a certain point the resistance of a wire remains constant, without change. By this we mean that the resistance offered to one ampere or to ten amperes will be identical, but when the load becomes such that the temperature of the wire rises above normal then its resistance also begins to rise, with consequent loss in voltage, or power, which loss will be registered on the watt-meter. The voltage consumed through excessive resistance caused by overloading the wire represents waste.

HOW MUCH RESISTANCE.—Broadly speaking, the amount of resistance allowable in an electric circuit is:

For the transmisssion of any given amperage the most economical condition is one where the line resistance is such that the value of the energy wasted in heat in overcoming the resistance of the line will be equal to the interest per annum on the original cost of the wires of the circuit plus the cost of installation.

This may be adopted as a safe guide. In practice it means that if, for instance, the projection room feed wires are offering sufficient resistance to cause voltage drop representing enough waste energy to more than pay interest on the cost of new conductors of larger size, then it will be true economy to install the new conductors.

Under "Figuring Voltage Drop" our readers will be instructed how to determine the voltage drop and loss in any given circuit, so that they may apply the foregoing in practice:

WIRE CAPACITIES.—The National Board of Fire Underwriters, whose ruling must be followed in matters of this kind, else insurance cannot be had on the building, has adopted the amperage rating recommended by the American Institute of Electrical Engineers. This rating is given in wire capacity table No. 1, which determines the number of amperes which any ordinary commercial copper electrical conductor may be allowed to carry. In the wire capacity table "B & S" means "Browne & Sharpe" wire gauge, which is the standard in this country. It is also known as the "American Standard" wire gauge. For reasons why rubber covered insulation wires have a lower amperage rating than other insulations see page 83.

Table No. 2 may be used by the projectionist for figuring the actual resistance, in ohms, of his various copper circuits. For instance, if the projection room feed circuit has a total length of 75 feet, and is of No. 5 copper wire, referring to table 2 we ascertain the fact that No. 5 copper has .3174 of an ohm resistance per one thousand feet, or .0003174 of an ohm per foot, and since the circuit is 75 feet long, hence has 150 feet of copper, the total resistance would be found by multiplying .0003174 by 150. (Continued under table 1A).

TABLE NO. 1—COPPER WIRE CAPACITIES.

[Note: Tables 1 and 1A are taken direct from the "National Electrical Code."]

Table No. 1. Allowable Carrying Capacities of Wires.

B. & S. Gauge	Diameter of Solid Wires in Mils	Area in Circular Mils	Table A Rubber Insulation Amperes	Table B Varnished Cloth Insulation Amperes	Table C Other Insulation Amperes
18	40.3	1,624	3		5
16	50.8	2,583	6		10
14	64.1	4,107	15	18	20
12	80.8	6,530	20	25	25
10	101.9	10,380	25	30	30
8	128.5	16,510	35	40	50
6	162.0	26,250	50	60	70
5	181.9	33,100	55	65	80
4	204.3	41,740	70	85	90
3	229.4	52,630	80	95	100
2	257.6	66,370	90	110	125
1	289.3	83,690	100	120	150
0	325.	105,500	125	150	200
00	364.8	133,100	150	180	225
000	409.6	167,800	175	210	275
		200,000	200	240	300
0000	460.	211,600	225	270	325
		250,000	250	300	350
		300,000	275	330	400
		350,000	300	360	450
		400,000	325	390	500
		500,000	400	480	600
		600,000	450	540	680
		700,000	500	600	760
		800,000	550	660	840
		900,000	600	720	920
		1,000,000	650	780	1,000
		1,100,000	690	830	1,080
		1,200,000	730	880	1,150
		1,300,000	770	920	1,220
		1,400,000	810	970	1,290
		1,500,000	850	1,020	1,360
		1,600,000	890	1,070	1,430
		1,700,000	930	1,120	1,490
		1,800,000	970	1,160	1,550
		1,900,000	1,010	1,210	1,610
		2,000,000	1,050	1,260	1,670

1 Mil = one one-thousandth (0.001) of an inch.

Varnished cloth insulated wires smaller than No. 6 may be used only by special permission.

Note: For insulated aluminum allow 84 per cent. of Table 1 capacity rating. The Board of Fire Underwriters does not recognize anything of less than No. 18 wire and **nothing less than No. 14 may be used for interior circuit wires.**

TABLE NO. 1A.

STANDARDIZED STRANDING

Strands			Cable		Allowable Carrying Capacities in Amperes		
No. of Strands	Mils Dia	B & S. Gauge No.	Area in Cir. Mils	Outside Dia. over Copper	Table A Rubber Insulation	Table B Varnished Cloth Insulation	Table C Other Insulation
7/	25	22	4,490	.075	15	18	20
7/	32	20	7,150	.096	20	25	25
7/	40	18	11,370	.120	25	30	35
7/	51	16	18,080	.153	35	40	50
7/	64	14	28,740	.192	50	60	70
7/	81	12	45,710	.253	70	85	90
7/	91	11	58,000	.273	80	95	110
7/	102	10	72,680	.306	90	110	130
19/	64	14	78,030	.320	100	120	150
19/	72	13	98,380	.360	125	150	175
19/	81	12	124,900	.405	150	180	210
19/	91	11	157,300	.455	175	210	250
19/	107	*	217,500	.540	225	270	325
19/	114	9	248,700	.570	250	300	350
37/	91	11	306,400	.637	275	330	400
37/	97	*	347,500	.679	300	360	450
37/	102	10	381,200	.714	325	390	500
37/	116	*	484,300	.798	400	480	600
61/	102	10	633,300	.918	475	565	700
61/	107	*	698,000	.963	500	600	750
61/	114	9	788,500	1.030	550	660	825
61/	121	*	893,100	1.090	600	720	900
61/	128	8	1,007,000	1.150	650	780	1000
91/	114	9	1,191,000	1.250	725	870	1125
91/	128	8	1,502,000	1.410	850	1020	1350
127/	114	9	1,660,000	1.480	900	1100	1460
127/	128	8	2,097,000	1.660	1100	1300	1700

*These individual strands are odd sizes not listed in the American or B. & S. Wire Tables.

Having this data in hand we have only to divide the current in amperes by the resistance of the circuit in ohms to get the voltage drop.

Tables 1 and 1A are both correct for any number of amperes up to the capacity of the wire, or, in other words, until the load becomes great enough to cause a distinct rise in temperature. For instance: If you propose to carry only 5 amperes on a No. 5 wire you would have exactly the same total resistance you would have if you carried 50.

Theoretically this is not strictly true, since there is a rise in temperature with any increase in current, but it is true in practice, nevertheless, by reason of the fact that with any load less than the wire's capacity the temperature rise is too slight to have appreciable effect.

For the convenience of our readers we append hereto table No. 2, which gives the resistance of copper wire at normal temperature.

TABLE NO. 2

RESISTANCE OF COPPER WIRE.

Am. Gauge, B. & S. No.	Resistance at 75° F., International Units			
	Ohms per 1000 Feet	Ohms per Mile	Feet per Ohm	Ohms per Lb.
0000	0.04964	0.2621	20147.	0.00007758
000	0.06261	0.3306	15972.	0.0001234
00	0.07894	0.4168	12668.	0.0001962
0	0.09945	0.5251	10055.	0.0003114
1	0.1255	0.6627	7968.	0.0004960
2	0.1583	0.8360	6316.	0.0007894
3	0.1966	1.054	5010.	0.001254
4	0.2516	1.329	3974.	0.001994
5	0.3174	1.676	3150.	0.003173
6	0.4002	2.113	2499.	0.005043
7	0.5044	2.663	1982.	0.008013
8	0.6361	3.358	1572.	0.01274
9	0.8026	4.238	1246.	0.02029
10	1.011	5.340	988.8	0.03220
11	1.277	6.743	783.1	0.05135
12	1.609	8.496	621.5	0.08154
13	2.026	10.70	493.6	0.1293
14	2.556	13.50	391.2	0.2058
15	3.221	17.01	310.4	0.3268
16	4.070	21.49	245.7	0.5216
17	5.118	27.02	195.4	0.8249
18	6.466	34.14	154.6	1.317
19	8.151	43.04	122.7	2.092
20	10.26	54.15	97.51	3.312
21	12.93	68.26	77.35	5.263
22	16.41	86.62	60.95	8.476
23	20.56	108.6	48.63	13.32
24	26.00	137.3	38.47	21.28
25	32.78	173.1	30.51	33.84
26	41.54	219.4	24.07	54.35
27	52.09	275.0	19.20	85.44
28	66.17	349.4	15.11	137.9
29	82.27	434.4	12.15	213.1
30	105.1	554.7	9.519	347.6
31	131.7	695.4	7.592	546.3
32	166.2	877.4	6.018	869.6
33	209.5	1106.	4.772	1383.
34	264.6	1397.	3.779	2205.
35	333.7	1762.	2.996	3507.
36	420.1	2218.	2.380	5558.
37	530.4	2801.	1.885	8860.
38	669.9	3537.	1.493	14131.
39	843.0	4451.	1.186	22378.
40	1065.	5625.	0.9387	35734.

When figuring copper wire resistance, still another equation enters, however, and a very important one, too, viz., drop in voltage.

MIL-FOOT STANDARD OF RESISTANCE.—The figuring of the resistance of a wire of any size or length is a simple matter, providing the standard of resistance for that particular material be known.

The accepted standard of resistance is the resistance of a wire one circular mil in cross-section (one one-thousandth of an inch in diameter) and one foot in length, made of the same material as the wire it is purposed to measure. This is what is known as the "Mil-foot standard of resistance." The resistance of such a wire, when made of ordinary commercial copper, is given by standard text books as 10.5 ohms. That is to say, a wire one foot in length and one one-thousandth of an inch in diameter (one mil area of cross-section), made of ordinary commercial copper, at normal temperature (75° F. or 24° C.), will have a resistance of 10.5 ohms.

FIGURING RESISTANCE OF COPPER CIRCUITS.—And now let us proceed to apply the foot-mil standard in measuring wires. Suppose you have a wire 400 feet in length and 1 circular mil cross section (1/1000 of an inch in diameter), made of ordinary commercial copper. It is evident that if one foot of such a wire has a resistance of 10.5 ohms, 400 feet would have a resistance four hundred times as great, or $10.5 \times 400 = 4200$ ohms. The resistance of a wire of given length, however, decreases as its diameter or area of cross-section is increased. If our 400-foot wire has a diameter of 250 mils, it will have a cross-section equal to $250 \times 250 = 62{,}500$ C.M., and it follows that its resistance would be equal to the resistance of 400 feet of one-mil wire (4,200 ohms) divided by the C.M., cross-section of the larger wire (62,500), since it would be, in effect, equal to 62,500 wires, each one circular mil in cross-section, or one mil in diameter. From this we get the rule:

To find the resistance of a copper wire, multiply its length in feet by 10.5 and divide that product by its area in circular mils.

In measuring circuits, however, it is customary to take the one-way length and double the mil-foot standard, thus: multiply the one-way length of the circuit by 21 ($10.5 \times 2 = 21$) and divide that product by the area of the wire in the circuit; expressed in circular mils.

For example: What is the resistance of a two-wire projection room feed circuit 75 feet in length—size of the wire No. 5? If we were measuring only one 75-foot-long wire we would apply the above rule, using 10.5 as the standard of resistance, but as a matter of fact a circuit 75 feet long has 150 feet of wire, and for convenience's sake we double the mil-foot standard, instead of doubling the wire length.

In Table 1, page 70, we find that No. 5 wire has a cross-section of 33,088 C.M. We then have the problem:

$$\frac{\text{Length of circuit} \times 21}{\text{C.M. area of wire}} = \frac{75 \times 21}{33{,}088} = .0475 + \text{ of an ohm, which is}$$

the resistance of the circuit. This rule is, of course, based on the proposition that the wire will not exceed 75 degrees F., or 24 degrees C. However, the rise and fall in temperature caused by ordinary climatic conditions is not sufficient to materially affect the result. In fact, resistance does not begin to rise appreciably until the temperature has increased sufficiently to be sensible to the feeling; beyond that point it increases very rapidly with the temperature.

FIGURING VOLTAGE DROP.—We think it advisable to provide the accepted formulas for figuring voltage drop, even though the projectionist and the theatre manager may only have use for them on rare occasions.

The question of voltage drop is given altogether too little consideration in theatres. In the following formulas

L stands for one-way length of circuit.
A stands for cross-section in circular mils.
e stands for voltage drop, in volts.
E stands for voltage of circuit.
I stands for current in amperes.
R stands for resistance in ohms.
P stands for voltage drop, expressed in percentage.

Where the length of the circuit, the area of cross-section of the wire, together with its mil-foot standard of resistance, is known, the ohmic resistance may be calculated according to:

$$\text{Formula No. 1: } R = \frac{21 \times L}{A}$$

in which 21 is a constant equal to twice the resistance of the mil-foot standard for copper wire. Twenty-one and the one-way length of the circuit are used, instead of 10.5 and the total length of the two wires, merely for the sake of convenience.

Example: What is the resistance of a circuit of No. 6 copper wire having a one-way length of 200 feet? Using formula No. 1, substituting figures we have

$$\frac{21 \times 200}{26{,}250} = \frac{4200}{26{,}250} = .16 \text{ of an ohm.}$$

Formula No. 2—$e = I \times R$, meaning that voltage drop equals amperes multiplied by resistance of the circuit. Example: What is the voltage drop of a circuit of copper having .16 of an ohm resistance and carrying 50 amperes? Substituting figures we have: $e = 50 \times .16$, or an 8 volt drop.

Formula No. 3: $e = \dfrac{21 \times 1 \times L}{A}$, in volts. Example: What is the voltage drop of a copper circuit of No. 6 wire having a 200 foot one-way length, carrying 50 amperes? Substituting figures we have: $e = \dfrac{21 \times 50 \times 200}{26{,}250} = 8$ volts drop.

Formula No. 4: $A = \dfrac{21 \times 1 \times L}{e}$, in circular mils. Example: What size of wire (area of cross-section) is necessary to give an 8 volt drop in a copper circuit having 200 feet one-way length, carrying 50 amperes? Substituting figures we have: $A = \dfrac{21 \times 50 \times 200}{8} = 26{,}250$ circular mils.

Formula No. 5. When the voltage drop is expressed in percentage the following formula may be used to determine the area of cross-section of wire necessary to give the desired drop. $\dfrac{2100 \times 1 \times L}{E \times P}$ = area of cross-section in circular mils. Example: Suppose you want a circuit having a one-way length of 60 feet to carry 100 amperes with a 3 per cent. voltage drop; voltage of circuit 110. Substituting figures we have: $\dfrac{2100 \times 100 \times 60}{110 \times 3}$, which equals 38,181 circular mils, and since a No. 5 wire would be too small (see table No. 1) we would have to use No. 4, which would be a little too large and would not give quite the 3 per cent. drop.

Formula No. 6.—If the power is given in watts, the required area of cross-section of wire to give a desired voltage drop may be figured thus: $\frac{2100 \times W \times L}{P \times E}$ equals area of cross-section in circular mils, W standing for watts, of course.

And now let us apply the foregoing in practice. A two-wire projection room feeder supplies 50 amperes at a distance of 200 feet from the house switchboard; we will assume that a 5 per cent. drop in voltage is allowed, the supply voltage being 110. What size wire should be used? Referring to the formula we select No. 5, and, substituting figures, the necessary size of wire is found as follows:

$$A = \frac{2100 \times 50 \times 200}{110 \times .05} = 38{,}181 \text{ circular mils}$$

Turning to our capacity table we find that a No. 5 wire has an area of 33,088 C.M. and a No. 4 has 41,740, so that while a No. 4 would be largely in excess of the requirements, a No. 5 would be too small.

If this energy were used for ten hours a day for 300 days and the cost of the energy were 8 cents per k.w. hours, the total yearly cost would be:

$$\frac{50 \times 110 \times 300 \times .08}{1000} = \$1{,}320,$$

5 per cent. of which is $66, which latter amount would express a yearly loss due to the 5 per cent. drop when using 50 amperes at 110 volts, and at a cost of eight cents per K.W. Once the nature of the problem is understood it is an easy matter to determine the best course of procedure. Sixty-six dollars represent 8 per cent. on approximately $800, so that if larger conductors can be installed for that sum, or less, and the loss thus reduced, it certainly will pay to do it, since paying out sixty-six dollars a year for wasted electric energy is precisely the same as paying that sum out in the form of interest.

Of course, we have assumed an arbitrary current cost of eight cents per K.W. If current is had for less, the figures will be changed. We have, we hope, made the nature of the problem clear, and having done that must leave it to the individual projectionist and exhibitor to figure out his own problem.

The data supplied is important, because by its intelligent application it will very often be found that much money is wasted in the excessive resistance of circuits, which could be avoided by installing wires of larger size. It is therefore, we repeat, essential that the projectionist and manager have a good working knowledge of matters of this sort.

THE MEASUREMENT OF WIRES.—The area of cross-section of electrical conductors of various kinds is measured either in square or circular mils, the latter being used for round wires and the former for square or rectangular conductors.

A circle measuring 1/1000 of an inch in diameter is called a "circular mil," the same being commonly abbreviated "C.M."

A round wire 1/1000 of an inch in diameter is said to have an area of cross-section of one circular mil, "cross-section" being the surface of the end of a wire.

The area of round wires is directly proportioned to the square of their diameters, the calculation being made in circular mils.

"Squaring the diameter" means multiplying the diameter by itself, thus: if a wire be 10 mils in diameter, then $10 \times 10 = 100$ is the square of its diameter, hence the area of its cross-section in C.M.

Let us consider a wire having a diameter of ¼ of an inch. Since one inch is equal to one thousand thousandths (1000/1000), the diameter of the wire expressed in thousandths of an inch, or mils, would be equal to $1000 \div 4 = 250$. A wire ¼ of an inch in diameter is, expressed after the electrical fashion, 250 mils in diameter, and since the area of cross-section of a wire in circular mils is equal to the square of its diameter in mils, it follows that our quarter-inch-diameter wire would have an area of $250 \times 250 = 62{,}500$ circular mils.

The circular mill area of any round wire may be found by measuring its diameter in thousandths of an inch, using a micrometer caliper or wire gauge for the purpose and multiplying the measurement thus obtained by itself. The result will be the C.M. area of the wire.

The capacity of any round wire may be found by measuring the wire diameter as above set forth, multiplying the measurement by itself and comparing the result with "Area in C.M." column in wire capacity table, page 70.

B. & S. WIRE GAUGE.—The accepted standard for wire measurement in this country and Canada is the American gauge, commonly known as the "Brown & Sharpe" gauge, which in practice is dubbed the "B. & S." gauge.

This gauge is illustrated in Fig. 7. In using the tool it is the slot, and not the round hole which determines the size of the wire. In using the gauge select the slot in which the wire fits snugly, without binding. A wire gauge of this type should have the width of the slot, or in other

Figure 7.

words the mil diameter of the wire which fits the slot, stamped opposite each slot on one side of the gauge, and the number of the wire which fits the slot on the other side. For example, opposite the slot in which a No. 16 wire fits will be found the No. 51, meaning 51/1000 of an inch, or 51 mils diameter, the terms thousandths of an inch and mils being interchangeable. Note: This is not exactly accurate. The precise measurement is 50.0820, but there would not be room on the gauge to stamp such long numbers legibly.

MICROMETER CALIPER.—Wires may also be measured with absolute accuracy by means of a micrometer caliper such as is illustrated in Fig. 8.

This tool is, however, expensive; moreover the man unaccustomed to handling such tools would have difficulty in using it. Micrometer calipers made for the use of electricians have the wire size and their equivalent in mils stamped thereon. Thus: Looking at Fig. 8, if a wire measures 31.9 thousandths of an inch in diameter, we see that it is a number 20 wire. If it measures 162 thousandths of an inch (mils) we see that it is a number 6 wire, etc.

For measuring very small wires, such as the strands of an asbestos covered wire (usually a No. 30 or No. 31) the slot wire gauge is reliable only in the hands of an expert. If the projectionist desires to measure his asbestos covered wire

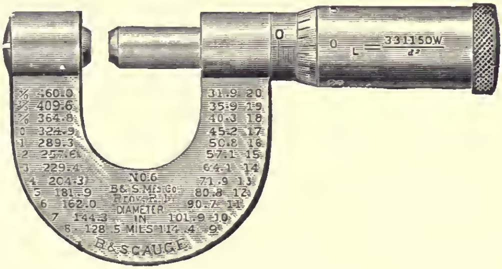


Figure 8.

strands and he has no micrometer caliper, it would be better to have a machinist measure a few of the strands with a micrometer. Every projectionist should own a wire gauge or micrometer caliper. If the former, it should be a good gauge, not one of the unreliable catch-penny affairs which are worse than nothing at all. The Brown and Sharpe Standard Wire Gauge for copper wires, illustrated in Fig. 7, is thoroughly reliable. It will serve all the purposes of the projectionist, except for the accurate measurement of very small wires.

DO IT NOW.

Insulation

INSULATION is for the purpose of confining the electric impulse, current or E. M. F. to the wire. Its purpose is to prevent electrical contact between wires of opposite polarity attached to the same generator. Put in other words, the purpose of insulation is to keep the wires from coming into electrical contact with each other, or with any object which might furnish an electrical path of conductivity to a wire of opposite polarity attached to the same dynamo or battery. Such a path of conductivity may be supplied by direct contact between two wires, by means of both wires coming into contact with a third wire or other object which will conduct electricity, or y both wires making contact with the ground. In short, insulation is to protect the potential of or on a wire from escaping to a wire of opposite polarity.

As has already been shown, various metals offer resistance in varying amount to the passage of electric current. It is also true that various materials other than metals offer a varying resistance to the passage of electric current, and while there is no material known which is an absolute non-conductor—through which the electric current cannot be forced if the voltage is raised sufficiently high—still there are materials which are considered as being and which are treated as non-conductors, because current cannot be forced through them by any ordinary commercial voltage. These substances are called "insulating materials" and at their head stands, in the order named, glass, porcelain and rubber.

Various natural substances, such as marble and slate, form excellent insulating materials for ordinary voltage. Asbestos, when dry, is also a very good insulator. Then, too, there are various insulating compounds, the composition of some of which are trade secrets. In practice these compounds are used to saturate some sort of braid or other material which after being so saturated is used for weatherproof insulations on wires to be used out of doors or to re-enforce the insulation of rubber covered wires.

R. C. AND WHAT IT IS.—Rubber covered wire consists of copper wire which has been coated with tin, upon which is laid a covering of pure rubber or rubber compound of homeogeneous character, over which is placed one or more outer coverings of braided cotton which have been soaked in a preservative fireproof insulating compound. Where copper wire is covered with rubber, or any of the rubber compounds, the tinning of the wire is very necessary, since the sulphur, universally present in rubber insulation is likely to combine with the copper, in which case the wire would in a very short time become corroded, and thus either very greatly weakened or perhaps entirely destroyed. The tinning of the wire prevents this, since because tin will not combine with sulphur, the rubber insulation has no effect upon it.

It is not the purpose of this work to enter into an exhaustive treatise on insulating materials, which subject would in itself fill a large volume. Our intent is merely to give the projectionist a general understanding of the proposition as a whole. Those who wish to study the matter of insulation exhaustively should visit their public library and consult standard electrical works which deal with insulation.

The current must be confined to the wires and made to pass from positive to negative through the paths provided, and through them only, the said paths being motors, incandescent lamps, arc lamps, et cetera. The ability of insulation to resist electrical action must increase with increased voltage, and its kind or type must vary with the service. The insulation known as "weatherproof" may be used wherever wires are stretched in an open area, and for out-of-door circuits, but for interior work only "rubber covered" wires may be used.

INSULATION RESISTANCE.—Where a test of the wiring of a building is required by the Inspection Department the wiring must comply with the following requirements:

The complete installation must have a resistance between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) not less than that given in the following table:

Up to	5	amperes	4,000,000	ohms.
"	10	"	2,000,000	"
"	25	"	800,000	"
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	50,000	"
"	800	"	25,000	"
"	1,600	"	12,500	"

The test must be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected only one-half of the resistance specified in the the table will be required.

TYPES OF WEATHER-PROOF INSULATION.—There are two types of weatherproof wire, viz., weatherproof and slow burning weatherproof. The insulation of the slow burning weatherproof consists of two coatings, one of which is fireproof and the other not. The fireproof coating is on the outside and comprises about 6/10ths of the total thickness of the insulation. The complete covering for size of wire from No. 14 to 0000 varies from 3/64ths to 5/64ths of an inch.

Fireproof insulation is not as susceptible to the action of heat as is ordinary weatherproof, which latter softens quickly under its influence. Fireproof insulation is not, however, suitable for outside work, being intended for interior work in warm, dry places, such as shops and factories. When so used, underneath it, next to the wire there must be a coating of rubber.

Slow burning insulation, which is still more fireproof than the slow burning weatherproof, is intended to be used in very hot places, where ordinary insulation would soon perish. Weatherproof insulation should consist of at least three layers of braid, each thoroughly saturated with a dense, moisture-proof compound, applied in such manner as to drive out any atmospheric moisture contained in the material, thus securing a covering which will not only have high insulating power, but which also will to a great extent be waterproof. The outer covering of this insulation is pressed down to a hard, dense surface.

Wire thus insulated is intended for use out-of-doors where there will be moisture and where fireproof qualities are not necessary. In general, weatherproof wires may be used only where the supports on which the wire is mounted are of insulating material and are depended upon for insulation, the covering being regarded merely as a precaution against accidental contact with other wires, or other objects.

In addition to these there is a varnished cloth insulation which may only be used in places free from moisture.

From the foregoing we may understand that the principal difference between rubber cover and other insulation lies in the fact that rubber cover insulation may be depended upon to do the actual insulating, whereas the other must depend, at least to a considerable extent, on the wire support itself for insulation. Rubber covered wire may be used anywhere weatherproof would be allowable, but not in places where slow burning weatherproof or fireproof insulation would be required.

Rubber covered wire of size No. 8 or less need have but one layer of braid and one braid wire No. 8 or less in size may be used in conduit. R. C. wire of greater size than No. 8 must have either two layers of braided material or a layer of tape with the rubber and a layer of braided material outside.

The reason rubber covered wire is rated at lower capacity than weatherproof is that rubber is easily and quickly injured by even a moderate amount of heat. Remembering that the passage of the current through wire generates heat in overcoming resistance, it will be readily seen that where an insulation which is easily injured by heat is used a wide margin of safety must be maintained.

WARNING.—R. C. is the only insulation permissible for use in conduit.

KNOWLEDGE IS POWER.

Wire Systems

TWO-WIRE SYSTEM.—The projectionist of today is not likely to come in contact with any except the two and three wire systems. It is true that the "Series Arc System" is still in use for street lighting, but it may be disposed of, so far as the purposes of this work be concerned, with the remark that it is not practical to connect a projection arc lamp to it. Should the projectionist encounter a series arc lighting system the only thing he can do is to let it severely alone. Should he attempt to connect a projection lamp to it, he will most likely put the whole system out of business, and may get himself severely hurt, or even killed.

The "Multiple Arc" or "Two Wire System" is illustrated in

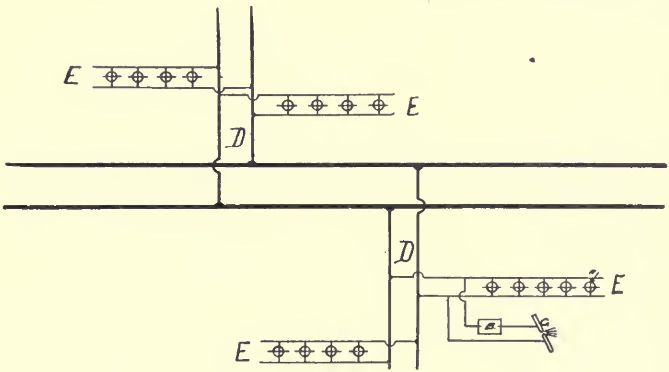


Figure 9.

Fig. 9, in which the heavy lines represent street mains coming directly from the power house, circuits D—D branch mains feeding a district or a street, and the thin lines E—E—E house, store, factory, theatre circuits, etc. We see a projection lamp attached to one of these latter circuits, all switches, fuses, etc., being omitted.

Assuming the system to be charged with ordinary commercial voltage, we may attach a projection lamp to the wires at any desired point, provided (a) the wires, switches, fuses, etc., be large enough to carry the current necessary for the arc, plus whatever else they will have to carry, without overload; (b) provided sufficient resistance be connected in series with the lamp to supply required number of amperes.

In the foregoing, by "commercial voltage" we mean anything up to, say, 250 volts, though it is practical to handle even as much as 500 volts by means of rheostatic resistance, and that is as high as the voltage will ever reach on any D. C. circuit. If the current be A. C., then a projection lamp may be attached at any desired point, provided the same precautions be taken as before named for D. C.; but if the voltage be in excess of, say, 110, you then should only attach your projection lamp to the secondary circuit of a transformer, which will automatically reduce the voltage line to a pressure suitable for use. This latter will be explained in detail under the heading of "Transformers," page 544.

In this connection, let it be remarked that the traveling projectionist will do well to procure a copy of McGraw's Electrical Directory, which is for sale by the McGraw Publishing Co., 239 West Thirty-ninth street, New York City. This book is issued yearly. It gives the necessary particulars concerning every electric generating plant in the country, such as the kind of current, voltage of the system, its capacity, etc.

We shall not remark further upon the two-wire system because it is in effect also dealt with in the three-wire system, which is the one most commonly encountered and which is to a very large extent merely the joining of two two-wire systems; therefore, if we went into extended detail on the two-wire system, much of what we would have to say on the three-wire system would be in the nature of a repetition, and there are too many things demanding attention to waste space.

THREE-WIRE SYSTEM.—The most widely used system for the distribution of light and power is what is known as the "three-wire system," illustrated in Fig. 10. The basic principle upon which this system operates is the fact that if two dynamos of the same characteristics be connected in series —the positive pole of one machine electrically connected to the negative pole of the other—the voltage between the positive and negative terminals of the combination thus effected, or in other words, the potential difference between the outer poles or terminals of the two machines, will be double that of either dynamo measured separately.

If each dynamo be a 110-volt generator, then the pressure between the outer terminals and the wires connected to them (wires E and F) will be 220 volts, though if at the same time the voltage be taken across the positive and negative terminal of either dynamo separately (between wires E and D or D and F), the reading would only be 110. It therefore follows that if a wire be attached to the outer terminals of two generators, as per wires E—F, Fig. 10, in which circles A and B represent 110-volt dynamos, and the other two terminals be joined by wire C, as shown, the voltage between these two wires will be double the voltage of either machine separately. If a

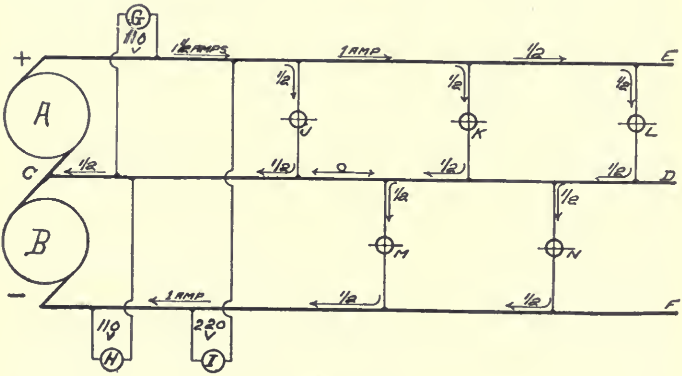


Figure 10.

third wire, D, be attached to connecting wire C, the voltage reading between either wires E—D or D—F, would be half that between wires E and F. In such a combination the center wire D is called the "neutral." The combination is such that current from either dynamo may be used without in any way affecting the other dynamo. Two outside wires E—F, are known respectively as the "true" negative and "true" positive of the combination, but

Neutral wire D is negative to dynamo A and positive to dynamo B, so that as a matter of fact it is both positive and negative, and when using current from either dynamo separately it will be either a positive, or a negative wire according to from which dynamo the current is taken.

If we connect a lamp or motor to wires E and D, then wire D will be just as truly negative as though dynamo B did not exist. If we connect to wires D and F, then wire D will be just as truly positive as though dynamo A did not exist.

G—H and I are voltmeters. Voltmeters G and H will each register 110 volts and voltmeter I will register 220 volts.

Put in another way, in the three-wire system we have what is in effect two complete two-wire systems joined together in such way that they may either be used separately at 110 volts, or jointly at 220 volts. The reason for such a combination is that it is economical in installation cost and maintenance, since the same electrical energy can be transmitted over a three-wire system that could be conveyed over two separate two-wire systems having wires of equal size; also, there is the added advantage of being able to use 110 volt incandescent lamps (which are very much better than 220 volt lamps) and either 110 or 220 volt motors.

Assuming the system shown in Fig. 10 to be in operation, its electrical action will be as follows: First let us switch off lamps J, L and N, leaving only lamps K and M burning. Assuming the lamps to consume 55 watts each, the amperage passing through any one of them when burning alone on 110 volts pressure would be $55 \div 110 = .5$ of an ampere; also, the amperage passing through two such lamps when burning in series at 220 volts would be $110 \div 220 = .5$ of an ampere, each lamp consuming 55 watts or 110 watts in all.

A peculiarity of the three-wire system is that lamps or motors connected to opposite sides will always, when possible, operate in series, **the current always seeking the true negative rather than the neutral wire.**

It therefore follows that with only lamps K and M burning, they would burn "in series" at 220 volts' pressure, hence ½ ampere of current would pass out from generator A and along wire E to lamp K. The current would pass through lamp K to the neutral wire, 110 volts of its E. M. F. being consumed in forcing the current through the resistance of the lamp filament, along the neutral wire to lamp M, through lamp M and back to generator B along wire F, the true negative of the combination. Under this condition no current at all would pass over the neutral wire, except between the points at which lamps K and M are connected to it.

Let us now switch on lamps L and N, whereupon instantly one ampere of current will follow along wire E up to the point where lamp K is connected to it. At this point the ampere will divide, one-half going through lamps K and M the other half continuing on and passing through lamps L and N, so that we now have one ampere flowing on the true negative between the generator and the point where lamp M is connected to wire F. The combination is now producing one ampere of current under 220 volts' pressure and is what the electrician would call "perfectly balanced."

BALANCED SYSTEM.—A three-wire system is said to be "balanced" when lamps or motors consuming precisely the same amount of current are attached between the neutral and either of the outside wires. In other words, when each "side" is carrying exactly the same load, under which condition everything operates in series and no current flows on the neutral between the generator and the first current using device attached to it. So long as this condition be maintained, the power-house neutral fuse could be removed without in any way affecting the system.

From the power-house viewpoint a perfectly balanced three-wire system is highly desirable. This ideal condition is, however, seldom or never realized in practice. There is practically always more load on one side than on the other, and amperage equal to the difference between the load on the two sides flows back to the generator on the neutral wire. If the system is a 110-220 volt one, and 26,400 watts are being used on one side and 24,200 on the other, then 26,400 minus 24,200 equal 2,200 ÷ 110 = 20 amperes will flow back to the generator on the neutral wire. The practical effect of this would be that one generator would produce 20 amperes (2,200 watts) more than the other.

For this reason officials of heavily loaded three-wire systems often object to projection arcs being connected to one side of the system. Both the dynamos are working close to capacity, and if a projection arc, which is in the nature of an intermittent load of considerable amount, be hitched to one side, that amount of load is thrown on one dynamo and the system is thus intermittently unbalanced.

However, if the projectionist is reducing his voltage with a rheostat there would be no advantage in connecting the projection arc across the outside wires, since although the amperage would remain the same, an amount of energy equal in watts to an additional arc of equal capacity would be consumed in the resistance necessary to take care of the extra 110 volts. Thus, instead of having one dynamo intermittently loaded with a projection arc, both generators would carry an additional load equal in watts to the arc amperage times 110.

If, however, an economizer, a mercury arc rectifier or a motor generator set be used for voltage reduction, then there is large advantage in connecting to the two outer wires, since there would then be no unbalancing effect and the total energy taken from the lines would be practically the same as when connected to one side at 110 volts. It may be accepted as fact that,

If the line voltage be reduced by means of a rheostat, the power company can have no reasonable excuse for compelling you to attach your projection arc to the outside wires of a three-wire system. Such a connection would cost exactly twice as much for electrical energy to operate the arc as it would cost if you were connected to one side at 110 volts, and places double the load on the system.

But to return to the consideration of Fig. 10, we have seen that with lamps K, L, M and N burning the system is balanced and no current flows back to the generator over neutral wire D. Let us now turn on lamp J in addition to lamps K, L, M and N. This will cause 1½ amperes to be generated, which will flow out on wire E to the point where lamp J is connected, whereupon it will divide up as shown, ½ ampere passing through lamp J, ½ through lamp K and ½ through lamp L. Between wires D and F ½ ampere will flow through lamp N and ½ through lamp M, but there is no lamp to balance lamp J, therefore the current flowing through it must return to the generator over neutral wire C. Hence we now

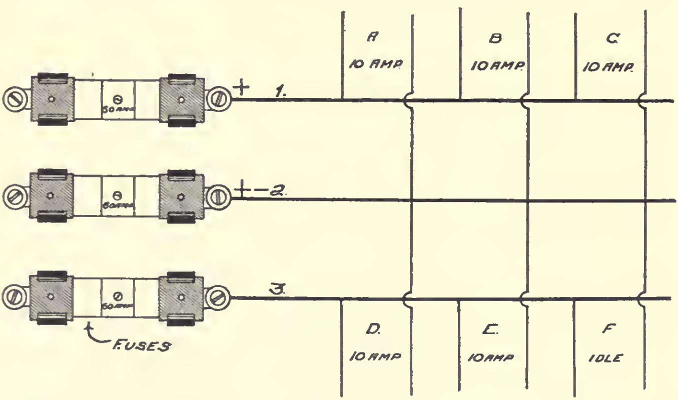


Figure 11.

have the system unbalanced by ½ ampere, with 1½, ½, 1 ampere flowing respectively in wires E, D and F between the lamps and the generators, and generator A producing ½ ampere more of current than generator B.

Insofar as current flow be concerned that is the way the three-wire system operates, but there are some points in connection with it which are very puzzling to the novice and more or less so to some more experienced men.

Fig. 11 is the diagrammatic representation of several house circuits fed by a three-wire service circuit, each wire of which is fused at 60 amperes. Between the neutral (central) wire and the upper wire, circuits A, B and C are connected, each of which is connected to apparatus using just 10 amperes. Between the neutral and the lower wire circuits D, E and F are connected the first two using 10 amperes each. Circuit F is idle.

Question: Would it be possible to attach a 25-ampere projection arc to circuit F, when the three main wires are only fused to 60 amperes and the circuit already loaded as shown?

The novice will probably answer, "No, the circuits are already using 50 amperes, and the addition of a 25-ampere arc would overload the fuses." The novice would, however, be in error, because the circuits are not using 50 amperes, but only 30, 10 of which are handled individually by the generator attached between the neutral and the upper wire. Circuits A, B, D and E will burn in series, as has already been explained, so that instead of 40 amperes at 110 volts, the lamps or motors on circuits A, B, D and E will work in series on 220, and only a total of 20 amperes will flow.

Circuit C will use 10 amperes at 110 volts, just as though wire 3 did not exist, as long as circuit F is idle. This will have the effect of causing the upper wire to carry 30, the lower 20 and the neutral to carry 10 amperes, so that the upper fuse will carry 30 amperes, the neutral fuse 10 amperes and the lower fuse 20 amperes. Under that condition the system is unbalanced 10 amperes, and the generator attached to the neutral and upper wire is carrying that much more load than is the generator attached to the neutral and lower wire.

Suppose we now connect a 25-ampere projection arc to circuit F. Circuit C now burns in series with circuit F to the extent of 10 amperes, but 15 amperes of the 25 must come from the generators over neutral wire, so that we now have the following condition: The upper fuse carries 30, the center fuse 15 and the lower fuse 45 amperes, and the generator attached to the neutral, and lower wires is generating 15 amperes more than its mate.

We therefore see that instead of being overloaded the fuses would actually be too large to properly protect the apparatus, were it not for the individual circuit fuses. To be fused absolutely right for the protection of the apparatus, we should now have a 30-ampere fuse in the upper, a 15-ampere fuse in the center and a 45-ampere fuse in the lower contact, though this is never done in practice, the fuses shown being intended to protect the main wires, the capacity of which would presumably be 60 amperes. The apparatus and smaller wires are protected by individual circuit fuses not shown in the diagram.

If your theatre is fed by a three-wire system it is important that the two sides be balanced as nearly as possible. If the theatre system is unbalanced and the neutral fuse should blow, then the effect is that of forcing the lights attached to one side above candle power, while those on the other side would burn below candle power.

It is always possible to tell exactly how much, if any, the load is unbalanced by connecting an ammeter into the neutral house feeder.

THREE-WIRE SYSTEM WIRE SIZES.—To figure wire sizes for three-wire circuits, proceed the same as for the ordinary two-wire system, considering only the two outside wires. Having determined the necessary capacity of the two outside wires, make the center wire the same size.

MR. EMPLOYER, YOU CANNOT REASONABLY EXPECT HIGH-CLASS WORK FROM YOUR MEN UNLESS YOU ENCOURAGE IT. THE UNION SCALE IS MERELY A MINIMUM YOU ARE EXPECTED TO PAY THE POOREST MEN. IF YOU WANT SOMETHING BETTER YOU SHOULD BE WILLING TO PAY FOR IT.

Switches

IT is essential that the projectionist be able to recognize the various types of switches met with in theatre work, also that he understand certain things with regard to their installation and proper care.

The various types of knife switches ordinarily encountered in theatre work are the double pole single throw (D. P. S. T.) double pole double throw (D. P. D. T.) three pole single throw (T. P. S. T.) and three pole double throw (T. P. D. T.).

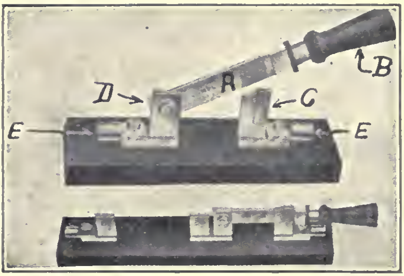


Figure 12.

In Fig. 12 we see at the top a S. P. S. T. knife switch mounted on a slate insulating base, slate being an insulating material for ordinary commercial voltages. A is the blade, B the handle, E E the terminals, D the hinge and C the contact. Important points in the care of switches are (a) that hinge D be kept set up snugly, the proper pressure being that which will cause the blades to remain in any position placed. If the switch is held upright, and when the blade is pulled out it falls down of its own weight making contact with C, then hinge D is too loose and should be tightened. The next important point is that contact C be so adjusted that there will be good, firm electrical contact between the blade and the contact clips C when the switch is closed. It is amazing how careless some projectionists are about such details. We have many times, in high class projection rooms, found switches loose and wobbly in their hinges, or making such poor contact at C that considerable heat was generated.

SWITCH INSTALLATION.—In the installation of knife switches, such as shown in Figs. 12 and 13, it is important that the switch be so placed that the tendency will not be for the switch to close itself by gravity. This means that the upper switch in Fig. 12 should, if mounted on a wall, always be placed either sidewise or with its handle up.

Switches often have fuses mounted on their base. In Fig. 12 the lower illustration shows an S. P. S. T. knife switch with fuse contact at the left, these contacts being designed to take what is known as the "knife blade" cartridge fuse. The fuses are not in place.

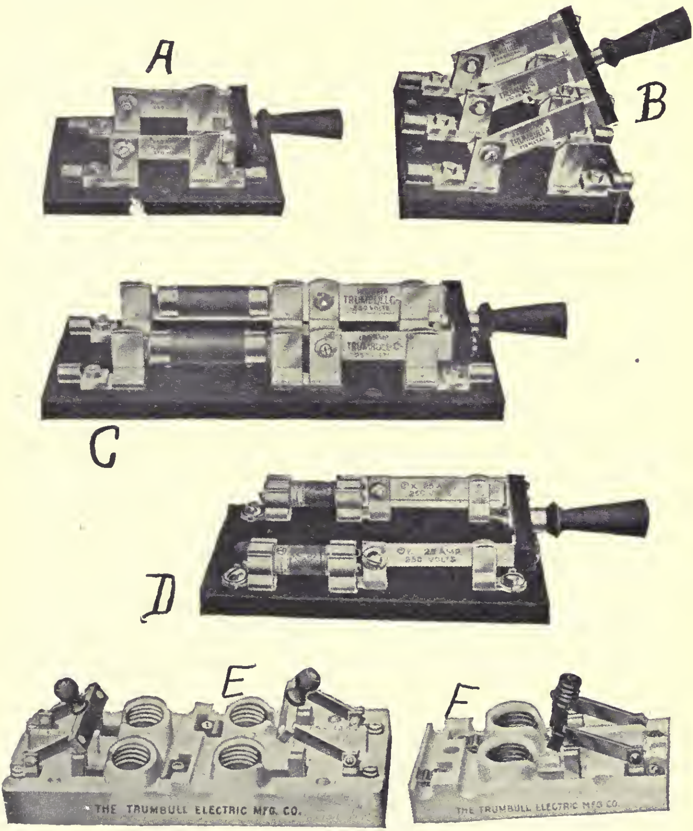


Figure 13.

In Fig. 13, A is a D. P. S. T. and B a T. P. S. T. knife switch, without fuse contacts; C is a D. P. S. T. knife switch with knife blade cartridge fuses, and D a D. P. S. T. knife switch with ferrule contact cartridge fuses. For explanation of the different kinds of fuse contacts see "Fuses," page 107.

In Fig. 13, E and F are types of porcelain base D. P. S. T. switches, with receptacles for plug fuses. This type of switch is called a "panel cutout." It is often used in building up panel boards, but may only be used to control individual circuits of low amperage.

ENCLOSED SWITCHES.—An enclosed switch is one having an individual protecting cover, usually of sheet metal which entirely encloses and protects all "live" parts of the switch. All projector switches are and must be enclosed switches, no other kind being permitted for this purpose. The enclosure of the switch by a metal covering is to protect the projectionist from possible shock by accidental contact with its live parts, as well as to prevent possible short circuits or injury to the switch by contact with various objects. It is important that the covering of enclosed switches be so made that it cannot come into contact with the live parts of the switch.

In connecting enclosed switches it is better that the blade end of the switch be dead when the switch is open. In fact that rule applies to all switches, though sometimes circumstances prevent its being adhered to.

LOCATION OF SWITCHES.—In the location of switches local conditions must, of course, largely govern, particularly in the smaller theatres, but the house switchboard should be so located that the man in charge of it will have an unobstructed view of the screen when at the switchboard. Unless this be done there is apt to be an imperfect handling of the house lighting at the beginning and the end of the show, or at other points where change in the auditorium lighting may be necessary, no matter what care may be taken to co-ordinate the work of the projectionist and the work of the switchboard man.

Switches governing emergency lights, which include all lights kept burning during the performance, should under no circumstances be placed on the main switchboard. You can never tell what an excited man will do, and in case of fire people inside the auditorium, including the employees, are apt to become excited. Some one might pull the emergency light

switches on the main switchboard, and thus set up a tremendously dangerous condition. Place the emergency light switches in the box office, where nobody can get at them but the ticket seller, and make him or her directly responsible for their handling.

In the projection room, local conditions will govern the placing of switches, but it should be remembered that nothing can possibly be gained by making things inconvenient for the projectionist. Wrongly located switches often cause much entirely unnecessary labor and annoyance; also inconveniently located switches cause delay, and make the proper handling of the program impossible.

The projection room incandescent lights should, as a whole, be governed by one switch, located within convenient reaching distance from working position at either projector. This will enable the projectionist instantly and fully to illuminate the room, or to cut off all lights instantly and conveniently, which latter is the best condition for projection. Each lamp socket should, however, have an individual snap switch.

This is of paramount importance, because it is impractical, not to say impossible, under conditions usually found in projection rooms, to produce the best possible screen results with incandescent lights burning, and the projectionist is more apt to extinguish his lights if there is a switch handily located with which he can put them all out or on with one operation than if he has to turn them off by using two, three or more switches. This is one of the seemingly unimportant points which is of great importance to results on the screen. See page 345 for modification.

USE OF TYPES OF SWITCHES.—Except for very limited purposes the use of the single pole knife switch is prohibited by underwriters' rules. So far as we are aware, none of the purposes for which a single pole switch may be used exists in a theatre, except in making certain rheostat connections, as will be explained under the heading "Rheostats."

The D. P. S. T. switch is the type ordinarily used to control all incandescent and projection circuits, except those controlled by triple pole or D. P. D. T. switches. The T. P. S. T. is used to control three-wire circuits where they enter a theatre, and wherever else the three-wire circuit may extend. D. P. D. T. switches are used in certain fuse connections, as will be explained under "Fuses." These switches are also used for connecting two separate two-wire supply systems, and for projection circuit connections under certain conditions. Also for polarity changing.

SWITCH MARKINGS.—It is required by underwriters' rules that switches have certain dimensions, according to the voltage they are to be used on, and the number of amperes they must carry.

Both the voltage and amperage capacity must be stamped on some part of a knife switch. Reject any switches not so stamped.

A switch may be used for a less amperage and less voltage than it is rated to carry, but never for a higher voltage or a higher amperage, thus: you might use a 500 volt 50 ampere switch on a 110 volt circuit and to carry any number of amperes up to 50. But you would not be permitted to use a switch of less than 50 amperes capacity for 50 amperes, or a 250 volt switch on a 500 volt circuit. The higher the voltage the further apart the blades of the switch must be placed, and the longer the switch blades must be.

Two hundred and fifty volt switches are the type almost universally used in theatres. There is no such thing as a 110 volt switch, the requirements for 110 and 250 being the same.

RECAPITULATION.—Be certain your switches have sufficient capacity to carry the amperage.

Be certain your switches are of proper voltage capacity.

Be certain your switches are so installed that the handle will not move downward in closing the switch.

Be certain the hinges and contacts of your switches are tight and in good condition. If contacts become roughened they may be smoothed with 00 sand paper which should be wrapped around a thin strip of metal for smoothing the inside of contacts C, Fig. 12.

Be sure the cross bar to which the switch handle is fastened is kept firmly attached to the blades. A loose, wobbly switch is an abomination; also it is an evidence of a careless, inefficient workman.

METAL CABINET.—Unless switch cabinets are built into the walls, all projection room switches and all other switches except those on the stage switchboard should be enclosed in a metal cabinet, such as is illustrated on page 104, the same to be equipped with a door which automatically closes, either by gravity or by a spring.

MAIN HOUSE SWITCHBOARDS.—Main house switchboards, particularly in medium sized theatres, are frequently placed in the projection room, in which case the entire auditorium lighting is under the direct care and supervision of the projectionist. He not only handles the switchboard itself, but the "dimmers," the latter being what amounts to a series of adjustable rheostats by means of which various incandescent circuits in the auditorium may be gradually dimmed down and finally extinguished.

In the "National Electric Code," copy of which may be secured by sending five cents in stamps to the National Board of Underwriters, Electric Department, 123 William Street, New York City, appear the following rules which must be strictly observed in the installation of switchboards:

a. Must be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

Switchboards must not be built up to the ceiling, a space of three feet being left, if possible, between the ceiling and the board. The space back of the board must be kept clear of rubbish and not used for storage purposes.

b. Must be made of non-combustible material.

c. Must be accessible from all sides when the connections are on the back, but may be placed against a brick or stone wall when the wiring is entirely on the face.

If the wiring is on the back, there must be a clear space of at least eighteen inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall.

d. Must be kept free from moisture.

e. Insulated conductors when closely grouped, as in rear of switchboards, must have a substantial flameproof outer covering.

Flame proofing must be stripped back on all conductors a sufficient distance from the terminals to give the necessary insulation distances for the voltage of the circuit on which the conductor is used.

As has been already said under "Location of Switches," page 94, the location of the main house switchboard will depend largely upon local conditions, and may only be properly determined by considering the peculiarities of each individual case. The best location in one theatre might be the worst in another.

In fixing the location, whether the switchboard be in the projection room or elsewhere, the architect or designer should be guided largely by the items accessibility and convenience, remembering always that if the switchboard be located outside the projection room it is essential it be in such position that the man handling it will have a good view of the screen or of the stage when at his post of duty. This latter is essential to the best manipulation of the lights, particularly if there is vaudeville, unless the lights be handled from the stage, as will most likely be the case in theatres where there is a stage.

MATTER OF SAFETY.—If the main house switchboard controlling the auditorium lights be located in the projection room there should always be an arrangement by means of which the auditorium can be lighted from a suitable location in the auditorium itself. Also if the main house switchboard be located in the auditorium there should be an arrangement by means of which the auditorium may be lighted from the projection room.

An emergency may at any time arise in which it is imperative that the auditorium be lighted instantly. This emergency may arise in the projection room, as in the case of a film fire, and unless the projectionist himself be able to switch on the lights, a space of time sufficient to set up a dangerous condition might very likely elapse before it could be done from the auditorium. It is also possible that an emergency would arise in the auditorium itself where safety would demand the instant lighting of the auditorium by the attendants.

It is quite possible for the projectionist to signal or telephone to the main switchboard attendant to switch on the lights, or vice versa, but in case of serious emergency the delay involved might be sufficient to cause a dangerous condition; also the signal apparatus or telephone might not be in good working order just at the crucial moment.

Personally we do not favor the placing of the main switchboard in the projection room except under conditions where there are always two men present in the room. We have long since taken the position, and see no reason to change it, that when a photoplay is "on," the projectionist should have nothing of any kind whatsoever to do except watch the screen and regulate those various things essential to a perfect screen result.

If, however, there are two projectionists, as is the case in many theatres, or even if there is a projectionist and a helper always present in the projection room, then the ideal condition is to have the auditorium lighting, including the dimmers, handled from the projection room. The projectionist may then work entirely from pre-arranged cues in the handling of the whole show, including the auditorium lighting, and there will be no division of responsibility. A proper co-ordination of the picture, the music and the lighting is of paramount importance, particularly in houses where the music and staging of the picture have been carefully worked out. An effect which, if properly worked, would be beautiful, may be ruined by just a few seconds delay in the manipulation of the auditorium lighting.

We cannot emphasize the importance of this latter too strongly. It was Samuel L. Rothapfel who first pointed the way to a truly artistic presentation of the photoplay upon the screen, and in the scheme of affairs as outlined by him, which is now followed, in greater or less degree, in all high class photoplay theatres, much depends upon close co-ordination of the auditorium lighting with the other various features of the program. It is therefore evident that the location of the main house switchboard is a matter for careful consideration by the management and the architect at the time the theatre is built.

THE "BOARD."—It is essential that both the projectionist and the man in direct charge of the theatre auditorium have a good understanding of the main house switchboard and its electrical connections. These switchboards are often imposing affairs, but once their connections are traced, they are simple indeed.

The main house switchboard will, or should, carry every circuit in the theatre, including the projection arc circuits and stage feeders, excepting the emergency light circuits, which latter must be attached to the theatre feed wires ahead of everything, including the main house fuses and switch, see page 103.

The main house switchboard will carry the (a) main fuses, placed ahead (on the street side) of everything except the exit and emergency circuits. These fuses will carry the entire house load, except the circuits just named, and except the stage, if the stage has a separate set of service wires, (b) the main switch, which kills everything but the exit and emergency lights, (c) fuses for every individual circuit in the house, including the projection room and stage feeders, if the latter are attached to the main board, (d) service switches for every individual circuit, including projection room feeders and stage feeders.

Of course what the main house switchboard will carry may be subject to modification by the peculiarities of the individual installation. In small, strictly moving picture houses, in which light effects are not attempted, it is much better to have auditorium lights that are not used during the show extinguished all at one time, rather than by pulling several small switches. In large houses, however, where there are many incandescent lights and circuits, this is neither a practical nor a desirable thing to do. In such houses dimers should always be used.

In figure 14 we have both a digrammatic and photographic

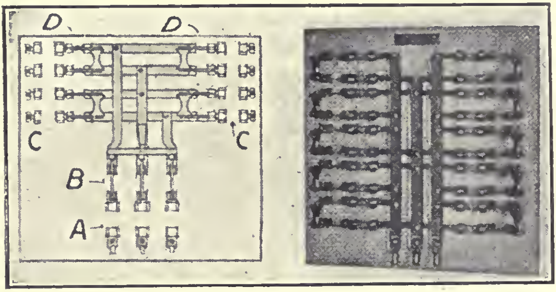


Figure 14.

representation of a small 3-wire switchboard, commonly known as a "panel board." In the diagram, A is the fuse contacts, B the main switch, C the house circuit fuse contacts and D the service switches governing individual circuits. All of this is seen photographically represented at the right, except that in the photographic representation the main switch and fuses are omitted, and there are five circuits on each "side," instead of three. Both in the photograph and the diagram the screw heads connecting the individual circuit feeder bars to the main circuit feeder bars form the key to the connection.

Taking the diagram for example, it will be observed that the center or neutral bar has a screw head over the second and third individual circuit bars, which means that the neutral bar is electrically connected to these two bars, or in other words, to the upper bar of the lower circuit and the lower bar of the upper circuit. The right hand short bar is connected to the lower bar of the lower circuit and the left hand feeder bar is connected to the upper bar of the upper circuit. It will thus be seen that the lower circuit is con-

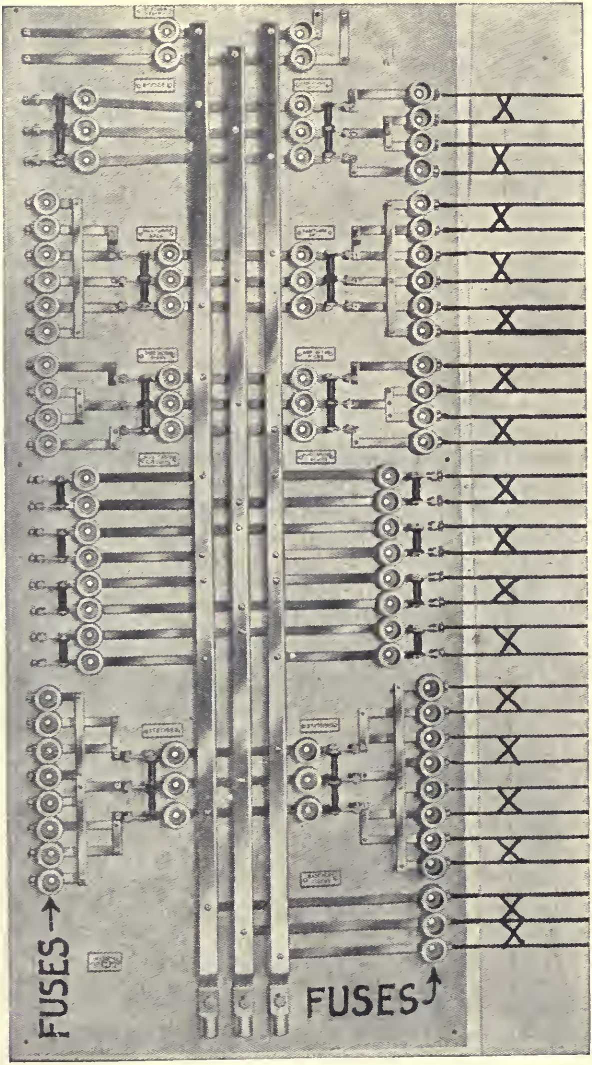


Figure 15.

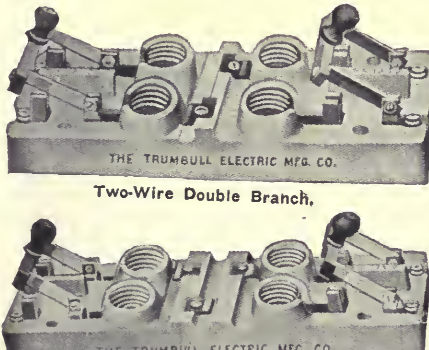
nected to the neutral and the right hand feeder bar, so that it is on the right hand "side" of the three wire cuicuit. The neutral and the left hand bar is connected to the upper circuit, so that circuit is on the left hand "side." We thus have one circuit connected to each "side," and if both circuits use the same number of amperes the load will be "balanced."

This forms the keynote to the connections of your big house switchboard. It is a bit puzzling for the novice to trace these connections, but look at it for a while and you will find that in all individual circuits one side is connected to the neutral and the other to one or the other of the main switchboard feeder bars, except in the possible case of the use of a 220 volt motor circuit, which would connect to the two outside bars or wires. It will be understood that where there is no screw head there is no connection between the feeder bars and circuit bars. Thus: The left hand feeder bar, Fig. 14, crosses the lower second and third bars without electrical connection and makes electrical connection to the top bar at the screw head. Where copper bars of this kind are used instead of wires they are commonly called "bus bars," though the term correctly applies to the copper bars which connect the power house generators to their circuits.

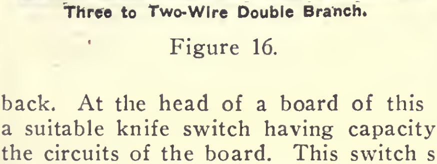
Fig. 15 is a photograph of a moderately large and somewhat complicated switchboard. On the right side the individual circuits are indicated by X. Study the contacts and you will be able to trace out the connections. Taking the next-to-the-top right hand circuit for example, we find it leaves the main bus bars in the form of a three-wire circuit, and that there are three plug fuses which protect the three-wire circuit as a whole. Just beyond the fuses is the handle of the T. P. S. T. switch, beyond which the upper bar connects to the upper wire of the upper two-wire circuit, the neutral connects to both the lower wire of the upper circuit and the upper wire of the lower circuit, and the lower bar connects to the lower wire of the lower circuit.

We thus have the three-wire circuit split up into two two-wire circuits, at the beginning of which are the individual circuit fuses which must be present on all individual circuits. To the left this circuit starts off and ends as a plain three-wire circuit. Above this circuit, at the very top of the bars, are two two-wire circuits, the neutral bar (see Screw Head) connecting to the lower circuit bar, the left hand bus bar to the upper left hand circuit bar and the right hand bus bar to the upper right hand circuit bar, and thus by a little care in observing the screw heads, which mean electrical contacts, we may readily trace out the connections of any house switchboard in which the bus bars show on the front of the board. If they are at the back of the board it complicates things a little for the beginner, but the action is traced out in the same manner. In Fig. 15 the main fuses and the 3-pole switch controlling the whole board are not shown.

PORCELAIN BASE CUTOUT SWITCHBOARDS.—In the smaller theatres it is an occasional practice to build up a switchboard of porcelain base panel cutouts, such as are illustrated in Fig. 16, and at E F, Fig. 13. Any number of these blocks may be used, and they may be had for either two or three-wire circuits, but may only be used for individual incandescent light or motor circuits of low amperage. These cutouts must always be mounted on an insulating base, and must be protected by a substantial metal cabinet similar to that shown in Fig. 17. It is permissible to form an insulating base for these blocks by placing either sheet asbestos or asbestos mill board not less than ⅜ inch thick at their back. At the head of a board of this kind there should be a suitable knife switch having capacity equal to that of all the circuits of the board. This switch should carry the main switchboard fuses.



Two-Wire Double Branch.



Three to Two-Wire Double Branch.

Figure 16.

If properly put together such a board is just as efficient, although it does not look so well as the regular slate base board.

EXIT AND EMERGENCY CIRCUITS.—The feeders for exit and emergency circuits must, as has already been set forth, be tapped to the main house service wires on the street side of the main house switch and fuses.

These circuits should be controlled by switches located

either in the box office or in the manager's office, and by no other switches.

Exit and emergency lights comprise the light and exit signs and all lamps in entrance foyer, stairway and other parts of the theatre used by the audience either regularly or in case of emergency, and are ordinarily left burning during the performance.

For the fusing of these circuits see page 120.

STAGE SWITCHBOARD.—It is not within the province of this work to deal with the stage switchboard, except to point out a few important elements which are demanded by the National Board of Fire Underwriters, and which make for safety.

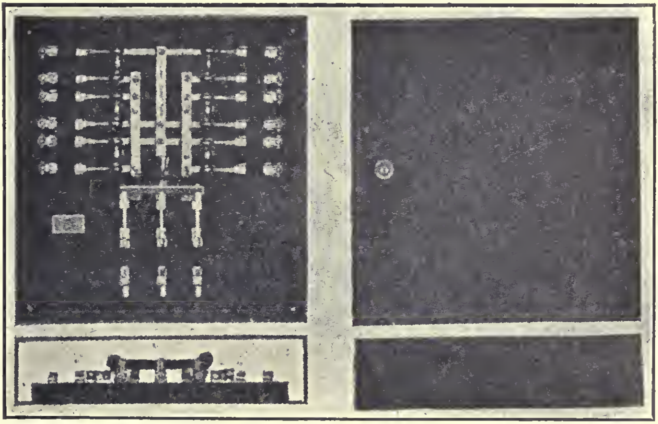


Figure 17.

The stage switchboard is ordinarily located on the proscenium wall. The common practice is to place it to the right of the proscenium as one looks towards the audience.

Stage switchboards should never be installed in any theatre, no matter how small, without first ascertaining the Board of Fire Underwriters' requirements for such installations.

It is required that the board be protected by a substantially constructed iron railing of certain height, located a certain distance from the board, and securely fastened to the floor. This guard is to protect the switchboard from

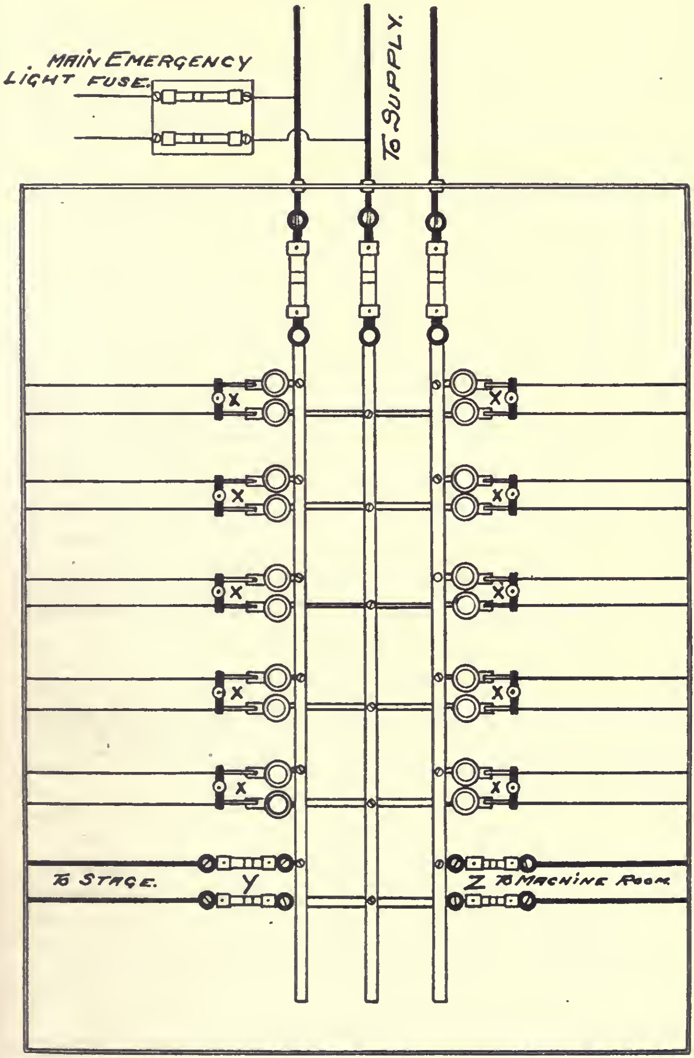

MAIN EMERGENCY
LIGHT FUSE.
TO SUPPLY.
X
TO STAGE.
Y
Z TO MACHINE ROOM

Figure 18.

accidental injury by being struck with moving objects, or from persons falling against it, as well as to prevent such accidental contact causing fire.

All fuses on a stage switchboard must be of an approved cartridge or plug type. It is absolutely forbidden, under any circumstances, to use a link or open fuse on any stage circuit.

The stage switchboard should carry main fuses and main switch controlling all current in the board. It will, of course, carry the various service fuses and switches for each individual circuit. All switches should be plainly marked with the name of the circuit they control, thus "white foots," "red foots," "blue foots," "first borders white," first borders green," etc.

The utmost care must be exercised that all switch contacts, etc., be kept in perfect electrical and mechanical condition, to prevent any possibility of heating which might, under some conditions, be extremely dangerous, and the whole installation should be carefully examined at regular intervals to see that it is in perfect condition.

Absolutely no one except the man in charge of the stage switchboard should under any circumstances be allowed to touch it while the performance is going on. The fewer people handling it at other times the better. Stage switchboards should always be wired from the back. While this is not absolutely demanded, it is safer and in every way very much better.

We do not care to deal further with the stage switchboard, since those contemplating the installation of one should accept the dictates of no authority except the city or state officials and the National Board of Fire Underwriters, with whom contact may be always had by addressing the National Board of Fire Underwriters, Electrical Department, 123 William Street, New York City.

BUILT-UP BOARD.—For those who prefer to build up a switchboard by using porcelain base switches, Fig. 18 will serve as a guide. For a small board ⅜ inch asbestos mill board makes an acceptable insulating support. Such a board may be built up quite inexpensively, and being installed in a metal cabinet such as that shown in Fig. 19, which may be had of any dealer in electrical supplies, will give very good service. The circuits marked X are incandescent circuits for the auditorium.

Fuses

AN electric conductor of given size will, as has already been set forth, carry only a certain given number of amperes of current without developing heat above normal temperature. See page 66 and Table No. 1 on page 70.

Ordinarily only the number of amperes consumed by the various motors and lamps attached to a circuit will flow over the wires of the circuit, and the combined capacity of lamps and motors attached to any circuit is never presumed to exceed the rated capacity of the wires. Many things, however, such as grounds, short circuits or a rise in the voltage may occur to cause an abnormal flow of current sufficient to overload wires, or if it be a rise in voltage then to overload the apparatus attached to the wires as well.

The fuse is a sort of electrical safety valve designed to act automatically and prevent overload of this kind.

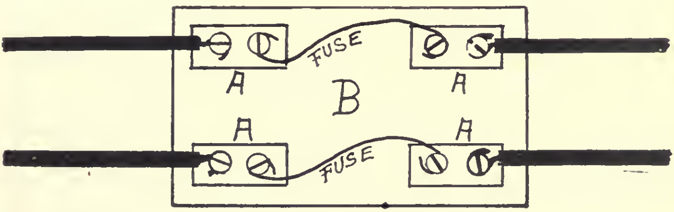


Figure 19.

In Fig. 19, we see an elementary set of fuses diagrammatically illustrated. The wires of a circuit are cut and their ends attached to terminals A-A-A-A, these terminals being mounted on insulating base B. Between these terminals, taking the place of the copper circuit wires, are two lengths of "fuse wire," which is wire composed of an alloy of metals, usually lead and tin, having a very low melting temperature and a high temperature co-efficient, which means that the resistance of fuse wires rises rapidly with overload.

The practical operation is as follows: The current capacity of the fuse wire is in no case presumed to exceed the rated capacity of the wires of the circuit they protect, and only to exceed the combined current consuming capacity of the lamps, if it be an incandescent light circuit, by a small margin, and only to exceed the combined current consuming capacity of the motors, if it be a motor feeder circuit, by 25 per cent.

Should the current flow increase, by reason of short circuit, grounds or rise in voltage, by an amount sufficient to cause overload, the fuse wire would become hot quickly, and, its melting temperature being far below that which would injure a copper wire, the fuse will melt and stop all current flow before the wires of the circuit, or even the apparatus attached thereto could be injured.

Assume, for example, a circuit of R—C wire rated at six amperes, with a sufficient number of incandescent lamps attached thereto to consume a total of five amperes. We would insert between the terminals in Fig. 19 fuses having a capacity of 5 amperes. As a matter of fact our 5-ampere fuses would actually carry more than that, because fuses are designed and intended to carry 10 per cent. more than their rated capacity, in order to allow for ordinary fluctuations in voltage.

Fuses protect a circuit because they melt at a temperature far below that necessary to injure copper wires.

Fuses protect the apparatus because they heat very quickly under overload, melt and stop all current flow before sufficient time has elapsed to injure lamps or motors.

Not only is the fuse a safeguard in the way we have described, but it is also an insurance against the operation of a faulty circuit. Because if the attempt is made to install a new fuse before the trouble which caused the blowing of the old one has been remedied, the trouble which blew (melted) the old fuse will also blow the new one.

The foregoing is the theory of the fuse and an explanation of its practical operation. In practice, however, raw fuse wire is now seldom employed, and never in a theatre, except in the form of "link" fuses, which are permitted, and even required by some cities for the fusing of projection circuits, but they are located in a fireproof projection room and must be placed inside an iron cabinet as well.

The types of fuses with which the motion picture projectionist is likely to come into contact, are the "plug" and the "cartridge," both of which forms are in general use in theatres. In fact they are the only fuses used in theatres, except as before noted with relation to the link fuse.

In Fig. 20, A is a cartridge fuse having "ferrule" (see XX in figure) contacts, and B is a cartridge fuse having knife blade contact, **the first named being permitted only on circuits carrying 60 amperes or less.** C and D are respectively the receptacles for fuses A and B.

CARTRIDGE FUSES.—A cartridge fuse consists of two terminals joined by a barrel constructed of insulating

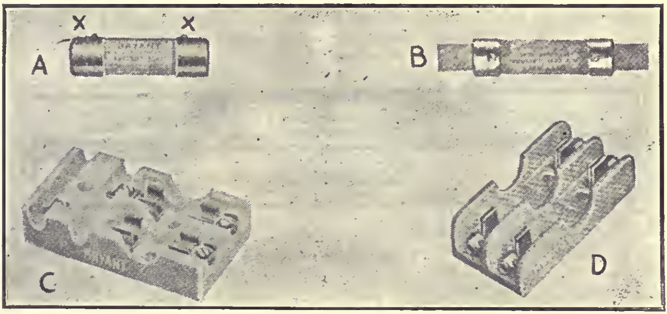


Figure 20.

material. Inside this barrel is a conductor made of fuse metal, which connects the two terminals, and a small wire known as the "pilot" wire also connecting the terminals and passing under a round spot on the paper label attached to the fuse, as per illustration in Fig. 21. An air chamber is used in some fuses, the idea being that the heat conduction through the confined area being slow, the temperature of that part of the fuse will rise rapidly, and always in the same ratio, which is persumed to establish a practically constant point of blowing. Except in the air chamber the fuse wire is surrounded by a powdered, non-conducting substance, designed to instantly break the arc when the fuse blows. On a paper label pasted on the outside of the barrel of the fuse is a small round spot under which the pilot wire passes. When the fuse blows the arc formed when the pilot-wire melts is presumed to char the paper, and thus turn the spot brown or black, although it does not always perform its duty in this respect. Table No. 4, which is taken verbatim from the National Electric Code of Fire Underwriters, gives the essential underwriters' requirements in the matter of dimensions for cartridge fuses. The underwriters require that the contacts have a certain

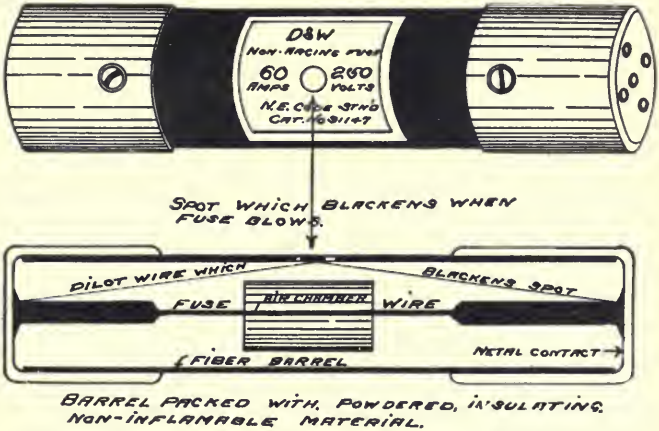


Figure 21.

minimum area, that the paper barrels have a certain minimum length and diameter, and that the fuses have a certain definite length over all for a given voltage and amperage.

PLUG FUSES.—Plug fuses are freqently used to protect theatre incandescent circuits. A plug fuse consists of a receptacle similar to that illustrated at B, Fig. 22, and a porcelain "plug," with a cap, usually of brass, as per A, Fig. 22, the brass cap which may or may not have a mica window through which one is presumed to view the fuse and ascertain its condition. Usually, however, this is not a practical thing to do, and the condition of the fuse may only

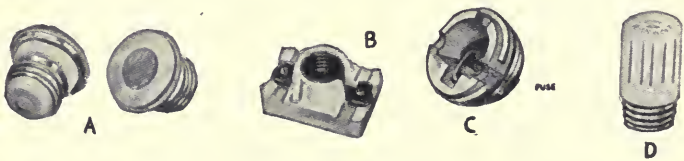


Figure 22.

be definitely ascertained by testing as hereinafter directed. C, Fig. 22, shows the porcelain base of the fuse plug with the cap off and the fuse in place. D, Fig. 22, is a special form of plug fuse to be used on amperage between 35 and 60, plug fuses in their regular form not being made in excess of 35 amperes capacity. They are not made in any form for capacity in excess of 60 amperes. Plug fuses may be used for any kind of work desired, up to the limit of their capacity. They are just as safe, and somewhat cheaper than cartridge fuses.

LINK FUSES.—The link fuse, illustrated in Fig. 23, is specified for use on projection circuits by the authorities of

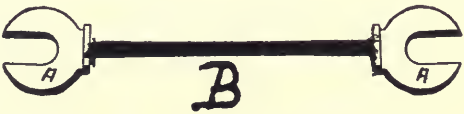


Figure 23.

New York City and by some other municipalities. This is by reason of the fact that it is difficult to "boost" a link fuse without the inspector being able to instantly detect the fraud.

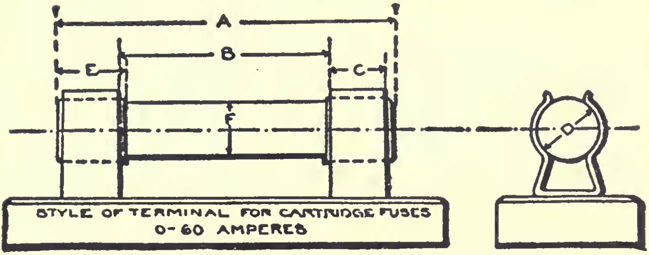
Where link fuses are used for projection circuit protection they must be located in a metal cabinet having a self-closing door, and this cabinet must itself be located inside the projection room.

The link fuse consists of copper terminals A A, Fig, 23, and fuse wire B, terminals A A being clamped under the terminal screws of a link fuse block.

BOOSTING FUSES.—Boosting a fuse consists in increasing its capacity by means of a small copper wire, or in case of a plug fuse a copper coin or something similar. Such practice is reprehensible in the extreme. It is, in fact, next door to criminal. A fuse is for the protection of wires and apparatus, and a boosted fuse no longer serves its purpose. It leaves the circuit without any protection at all, under which condition there is a possibility of serious damage to the apparatus, and of heating the circuit wires to the point where they will set the building on fire, or be fused by the heat.

With both cartridge and plug fuses it is possible for a projectionist possessed of more cunning than good sense to

TABLE OF DIMENSIONS OF THE STANDARD CARTRIDGE



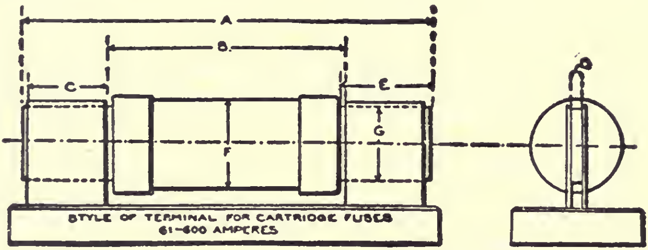
Form 1. CARTRIDGE FUSE—Ferrule Contact.

Voltage	Rated Capacity. Amperes		A Length Over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches.
Not over 250	0-30 31-60	Form 1	2 3	1 1¾	½ ⅝
	61-100 101-200 201-400 401-600	Form 2	5⅞ 7⅛ 8⅝ 10⅜	4 4½ 5 6	⅞ 1¼ 1¾ 2⅛
Not over 600	0-30 31-60	Form 1	5 5½	4 4¼	½ ⅝
	61-100 101-200 201-400	Form 2	7⅞ 9⅝ 11⅝	6 7 8	⅞ 1¼ 1¾

Table

NATIONAL ELECTRICAL CODE

ENCLOSED FUSE



Form 2. CARTRIDGE FUSE—Knife Blade Contact.

D	E	F	G		
Diameter of Ferrules or Thickness of Terminal Blades. Inches.	Min Length of Ferrules or of Terminal Blades outside of Tube. Inches.	Dia of Tube. Inches	Width of Terminal Blades. Inches.		Rated Capacity. Amperes.
9/16	1/2	1/2		Form 1	0-30
13/16	5/8	3/4			31-60
1/8	1	1	3/4	Form 2	61-100
3/16	1 3/8	1 1/2	1 1/8		101-200
1/4	1 7/8	2	1 5/8		201-400
1/4	2 1/4	2 1/2	2		401-600
13/16	1/2	3/4		Form 1	0-30
1 1/16	5/8	1			31-60
1/8	1	1 1/4	3/4	F'm 2	61-100
3/16	1 3/8	1 3/4	1 1/8		101-200
1/4	1 7/8	2 1/2	1 5/8		201-400

Number Four.

increase the capacity of his fuses almost indefinitely by "boosting," and such a trick could only be detected by a very close inspection. With the link fuse, however, this cannot be done so readily. Hence link fuses are recommended, under the conditions of installation named, for projection circuits.

Any projectionist or other person caught boosting fuses should be instantly discharged, and if he holds a license it should be suspended for a first offense and revoked for a second.

Never fuse above the rated capacity of the wires of the circuit.

Never fuse an incandescent lamp circuit above the combined amperage capacity of its lamps.

Never fuse a motor circuit above the rated capacity of the wires, or more than 25 per cent. in excess of the rated capacity of the motor or motors.

Underwriters' rules allow the fusing of a motor circuit to 25 per cent. above the capacity of the motor or motors attached thereto, provided, of course, the wires be large enough to accommodate the capacity of the motors plus the 25 per cent. overload.

It is physically possible to refill both cartridge and plug fuses, but it does not pay to do so, except in the case of special fuses made to be refilled.

THROW OLD FUSES AWAY unless they be of the "refilling" sort. Fuses which have blown have absolutely no commercial value. They should be thrown away immediately, else they may get mixed with the good fuses, with consequent possibility of vexatious delay—and such delays usually occur just at the worst possible time. If you keep your old fuses, and get them mixed with the good ones, for such delays you have no one but yourself to blame.

FUSING THE PROJECTION CIRCUIT.—The projection circuit wires are usually of size amply capable of carrying considerably more current than will ordinarily be used. Both the lamp and the wires of the circuit offer no chance of damage through a considerable temporary overload. It not only is a nuisance, but also impractical to have projection room fuses constantly blowing, and since the resistance of a projection arc lamp, especially if it be hand fed, is a highly variable quantity, the current flow will under any conditions vary considerably. We would therefore recommend for projection circuits the following, with the understanding that the ordinary current flow at the arc is what is referred to under the heading "normal amperage." Of course if the fusing is only done on the primary of a transformer (Compensarc Inductor Economizer, etc.) then due allowance must be made, as is set forth, see bottom of this page and next page.

Note—Fuses cannot be had in all the sizes named. This acts to limit the application of table No. 5.

Normal Arc Amperage	Fuse to	Necessary size R. C. portion of circuit wires	Necessary size asbestos covered portion of circuit wires
20	25	6	6
25	30	6	6
30	35	6	6
35	45	6	6
40	55	5	6
45	60	4	6
50	75	3	5
55	80	3	5
60	85	2	5
70	95	1	4
80	100	1	8+8
90	110	0	6+8
100	125	0	6+8
110	135	00	6+6
120	150	00	6+6

Table No. 5.

Projection circuit fusing table where rheostats are used for resistance.

Note—Asbestos covered stranded wires are not available in a size larger than No. 4. We have, therefore, given the necessary sizes for doubling. "8+8" means two No. 8 wires instead of the necessary No. 3 for 100 amperes, and a 6 and an 8 for 110 amperes.

Explanation—Wires must be large enough to accommodate the amperage capacity of the fuses without overloading. That portion of the circuit which is asbestos covered wire may be treated as weatherproof in this respect. See wire capacity table, page 70.

FUSING PROJECTION CIRCUIT FOR MOTOR GENERATOR.—Fusing the projection circuit where a motor generator rotary converter or mercury arc rectifiers is used is a simple matter. Ordinarily there should be fuses on both the motor and the generator side—on the intake and the output. Ascertain the amperage at the arc under normal conditions, and add about 20 per cent. to that amount, which will give the correct size for your fuses on the generator, or output side. The arc will, of course, be D. C., and for the purpose of figuring, the table on page 400 should be used. If, for instance, we have a 60-volt arc, the result of the arc amperage multiplied by 60 will give the arc wattage, which, divided by the voltage of the supply lines will give the intake amperage, or would give it if the machine had 100 per cent. efficiency. Few such machines, however, have more than a 65 per cent. efficiency; therefore, to the result so obtained, about 35 per cent. must be added in order to get the actual intake amperage thus: Assuming a line voltage of 110 and an arc wattage of 4200 (70 amperes with a 60 volt arc), then 4200 watts ÷ 110 volts = 38+ amperes, which, with the addition of 35 per cent. for losses in the machine itself, would be the amperage taken from the line. 35 per cent. of 38 amperes is 13 3/10th amperes, and, disregarding fractions, 13 + 38 = 51, which would be the total amperage taken from the line.

Of course, in the foregoing we are merely showing you how the thing is done. In order to get anything like an accurate result it would be necessary to measure your arc voltage with a voltmeter, and to measure the efficiency of your motor generator and the latter is not a thing the ordinary projectionist is equipped to do with any large degree of accuracy.

Assuming, however, that we find the intake amperage to be 51, we would install 55 ampere fuses on the intake line, to protect the motor, and since the generator output is 70 amperes it would only be necessary that we install seventy ampere fuses on the generator side, unless it were necessary to overload the machine at change-over, under which condition we would necessarily fuse for the overload, whatever it might be.

The foregoing is, however, qualified by the fact that if the generator is of higher voltage than the arc, then the arc amperage must be multiplied by the voltage of the generator instead of the voltage of the arc, since resistance will have to be used to cut down the voltage of the generator to the arc voltage, and voltage consumed in resistance counts just the same as that used in operating the arc.

SUPPLY OF FUSES.—The careful man will always keep plenty of fuses on hand. One never can tell when a fuse will blow. Sometimes an epidemic of fuse blowing occurs. It is bad to be caught without fuses, and the only insurance against it is an ample stock of surplus fuses.

In case you do get caught without fuses it is possible to protect the circuit reasonably well for a temporary period with one fuse, bridging the other fuse terminals with a copper wire. This, however, may only be tolerated as a strictly temporary expedient in case of emergency, until proper fuses can be procured. Emergencies of this kind should never occur.

A better emergency substitute is to make a fuse of copper wire. While such a fuse would be unreliable to a considerable extent, and from every viewpoint objectionable, still it may be used temporarily in an emergency to bridge one fuse contact, provided the other fuse be in good condition. We therefore give the fusing point of small copper wires.

TABLE NO. 6

Fusing Point of Copper Wires.

American (B. & S.) Wire Gauge	Fusing Current in Amperes
30	10
28	15
26	20
25	25
24	30
22	40
21	50
20	60
19	70
18	80
17	100
16	120
15	140
14	160
13	200

By combining strands of an asbestos covered wire, which usually are either No. 30 or 31, a fuse of almost any desired capacity may be had. Thus, five strands would be about right for 40 amperes.

WHEN FUSES BLOW.—When a fuse blows and the new one you install also immediately blows, it is conclusive proof that there is heavy overload, most likely due to a "short" or "ground," and the circuit must be left dead until the trouble is located. See testing for grounds, page 356.

A rise in voltage will operate to force more current through the lamps and motors, thus causing an increase in amperage which may blow the fuses. This condition will make itself evident by the incandescent lamps burning above candle power.

FUSE CONTACTS.—Should a fuse blow and the new one installed also blow, but only after a more or less extended time, it is likely the trouble will be found in the fuse contacts.

Examine the fuse contacts carefully, since loose or dirty contacts will generate heat, which may be sufficient to cause the trouble, especially if the fuses are working near their capacity.

TESTING FUSES.—Often when fuses blow it is difficult to tell which one of the two it is. We would therefore recommend the installation, at some convenient point, of a fuse tester made as per Fig. 24, in which A and B are the wires of any circuit that is always "alive," preferably the main feeders ahead of the switchboard fuses. If you attach at this point and the house is fed by a three-wire system, be

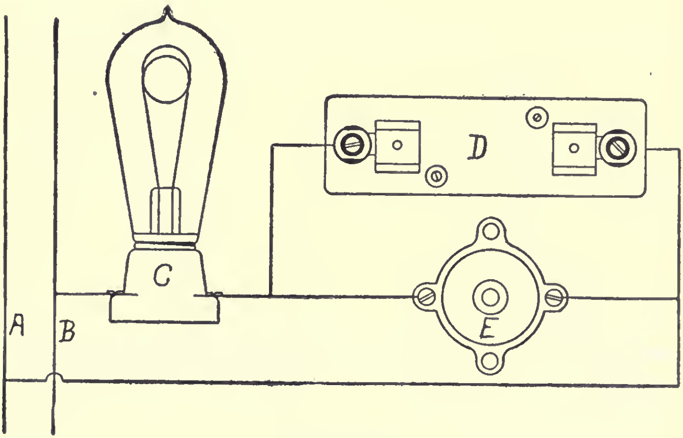


Figure 24.

sure to attach to one outside wire and the central or neutral wire, else you will have 220 volts on your tester instead of 110. D is an ordinary cartridge fuse receptacle, which must be ferrule or knife blade, according to the type of fuses used. E is a plug fuse receptacle. C is a receptacle and an incandescent lamp of the voltage of your current. When you put a fuse in either of the receptacles and lamp C does not light the fuse is worthless, and should be thrown away.

FUSE MARKINGS.—Cartridge fuse voltage and amperage rating are usually found marked on the paper label of their barrel. Plug fuses have their ratings stamped on the brass cap or the center contact and link fuses have, or should have their rating stamped on one of the copper contacts.

WHERE FUSES ARE INSTALLED.—In general, fuses are installed as follows: (A) Main service fuses, located ahead (on the street side) of the main house switch. These fuses carry all the current used in the theatre except the exit and other lights ordinarily left burning during the performance. Circuits carrying these latter, called emergency lights, should be attached to the feed wires ahead (on the street side) of everything else, and have service fuses of their own. See "Fusing Emergency Light Circuits," page 120.

Note—In some theatres the stage is fed by a separate set of feeders coming from the street mains, in which case this circuit will, of course, have main fuses of its own. (B) Fuses, usually on the main house switchboard, protecting the projection room service circuit. (C) Fuses on the main house switchboard protecting the service wires for the stage, if the stage takes its current through the main switchboard, as is usually the case. (D) Main fuses in the projection room which protect all projection room circuits; also individual service fuses on every separate projector arc circuit and projection room motor and incandescent circuit. (E) Fuses, ordinarily located on the main house switchboard, for each individual auditorium incandescent and motor circuit. (F) Fuses on the stage switchboard for each individual circuit, as well as main fuses carrying all stage circuits. (G) Fuses, usually located in the box office, carrying the entire emergency light system, as well as fuses for each individual emergency light circuit. (H) Fuses for each individual emergency light, particularly in the case of exit lights. (1) Fuses must be installed wherever a change in size (diameter) of wire occurs.

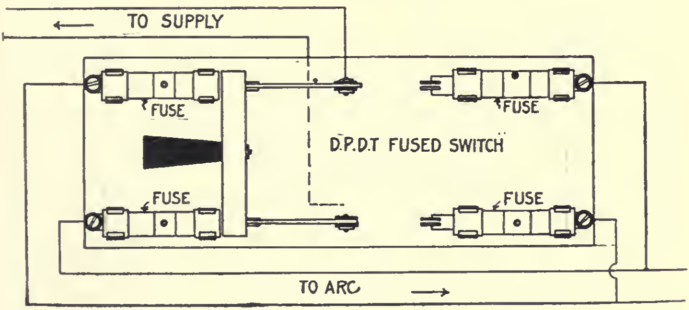


Figure 25.

FUSES FOR EMERGENCY LIGHT CIRCUITS.—Main fuses for emergency light circuits should be located ahead (on the street side) of everything else, including the main house switch. In addition to this, every separate emergency circuit must have fuses of its own, and still in addition to this it is an excellent plan to fuse each individual emergency light, especially the exit sign lamps, with one-ampere fuses. This latter is by reason of the fact that if trouble develops in a lamp, it will then blow only its own fuse, without disturbing the other emergency lights, where otherwise it would, or at least might put an entire circuit, or possibly even the entire emergency light system, out of business.

Every circuit, no matter how large or small it may be, must be protected by its own individual fuses, in addition to the main fuses carrying all circuits.

DOUBLE FUSING PROJECTION CIRCUITS.—The blowing of projection circuit fuses is a very annoying thing, since it stops the show and causes delay while new fuses are being installed. It does not necessarily follow that there is anything wrong because a projection arc lamp circuit fuse blows, particularly if the circuit is not fused much above the amperage being used. By installing two sets of projection circuit fuses as per Fig. 25, delays of this kind are avoided. When a fuse blows the projectionist has only to throw over the D.P.D.T. switch to cut in a new set of fuses, and unless there be something wrong with the circuit itself no appreciable delay will occur.

PUNCHING HOLES IN FILM IS NOTHING LESS THAN A CRIME. THE MAN WHO DOES IT SHOULD BE DISCHARGED IMMEDIATELY.

Wire Terminals and Wire Splices

IN the course of his duty it is necessary that the projectionist on the road with a traveling show, or the projectionist of the small-town theatre do more or less wire work, or at least that he have an understanding of many things connected with wire work.

TERMINAL LUGS.—Every wire should have a terminal lug, and except in cases where lugs will be subjected to heat, as in the projector lamp-house or at the rheostat, they should be soldered to the wire. Terminal lugs come in a number of forms, two of which are illustrated at E F, Fig. 26. In soldering a lug to the wire; proceed as follows: First measure the depth of the socket in the lug and cut off just sufficient of the insulation of the wire to allow its end to reach the bottom of the hole in the lug. Make the cut a square one, but be very careful not to cut clear through against the wire, because if you do the edge of your knife will most likely cut a tiny ring in the outside of the wire, which will to a large extent act the same as the cut made on a glass by a diamond. A knife cut on the outer surface of a copper wire weakens it greatly, so be careful.

Having removed the insulation, as per B, Fig. 26, scrape the bare wire-end perfectly clean. This latter is important, since otherwise the solder cannot make perfect contact between the wire and the lug. Next, first having made sure the inside of the socket of the lug is perfectly clean, hold the lug in the flame of a blow torch, or some other heat source, and melt sufficient solder into it to fill the hole about half full. Don't get the lug too hot, but just hot enough to make the solder thoroughly liquid. Now, first having rubbed on the bare wire end a little paste soldering flux, shove it down into the solder in the lug and hold it then until the solder cools.

CAUTION: Do not shove the wire into the lug with a quick push. If you do, the hot metal will probably squirt out and you may get badly burned. If the weather is cold it will be well to warm the end of the wire a little before shoving it into the lug. If these directions are followed you should have a mechanically strong and a perfect electrical joint.

In attaching terminal lugs to binding posts, be very sure that both lug and the binding post are perfectly clean. If they are not, scour them with a bit of sandpaper or emery cloth, or scrape them clean with a knife blade. It is particularly important that a copper wire be perfectly clean when it is joined directly to a binding post without a lug, since often a thin coating of oxidization will cover the metal, and this coating, while it is usually thin enough to be invisible, offers high resistance. A wire attached to a binding post by means of a properly soldered lug should offer no more resistance than the same length of the wire itself would offer, but if the connection be improperly made it may offer considerable resistance—perhaps enough to make the joint hot. This will itself operate to still further increase the trouble, since heat increases the resistance of metals.

The resistance of one imperfect joint might or might not amount to much, but that of several would waste many dollars worth of electrical energy in the course of a year, and it is well to remember that the meter registers all energy consumed, whether it be used in overcoming the useless resistance of poorly made joints, or in the production of light.

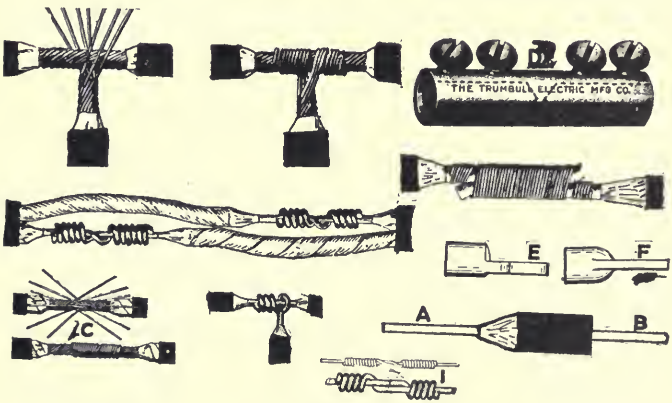


Figure 26.

WIRE SPLICES.—In Fig. 26 several correct methods of making splices are illustrated. First the insulation must be removed from the ends of the two wires to be joined for a distance of from 2 to 3 inches, according to the size of the wire.

The insulation should be whittled away just as you would whittle a lead pencil in sharpening it. Do not cut the insulation square off by running the knife blade around the wire. It makes a neat looking jub, but the knife blade is apt to cut a slight ring around the wire, which, as before set forth, acts much as does the scratching of the surface of glass with a diamond, causing the wire to break very easily at that point. The correct method of trimming off the insulation for the making of a splace is shown at A, Fig. 26, and the wrong way is illustrated at B.

After removing the insulation, the wire ends must be thoroughly cleaned, until they shine. This may be done with emery or sandpaper, or by scraping with a knife blade. Unless the wire be made perfectly clean there will not be good electrical contact. After being thoroughly cleaned the wire ends must be twisted together tightly, as at I, Fig. 26, after which the joint must be soldered.

Underwriter's rules provide that a wire splice must be made both mechanically and electrically perfect before soldering.

To solder, wet the metal thoroughly with a soldering fluid or its equivalent, which latter may be had from electrical dealers in stick or paste form. After thoroughly covering the joint with the fluid, or rubbing paste or stick flux on, hold both the wire and the end of a piece of wire solder in the flame of a blow torch until the solder melts and runs all through the joint.

CAUTION.—Care must be observed not to get the wire too hot, especially with small wire, since too much heat causes injury to the copper, reducing both its tensile strength and carrying capacity. If too much heat is used the solder will run through and out of the joint. If the soldering be properly done the joint will have greater mechanical strength and carrying capacity than the wire itself.

After soldering, the wire must be wrapped with insulating tape to the depth of the original insulation, the first layer of which should be what is known as rubber tape, with an outer covering of ordinary adhesive cloth tape.

What is perhaps the best method of making a splice in asbestos covered stranded wire is illustrated at C, Fig. 26, except that the strands should be divided into about six groups.

Under some conditions a wire connector similar to D, Fig. 26, may be used, but wire connectors such as this cannot be used to join the ends of stranded asbestos covered wire, or other stranded wire, unless the ends of the wire be first run full of solder, thus binding the strands together in a solid mass.

SOLDER FLUX.—An excellent soldering fluid is composed of the following. The mixture may be compounded by any druggist. It works well on either copper or tin.

Saturated solution of zinc chloride........5 parts
Alcohol ....4 parts
Glycerine ....1 part

TERMINAL LUGS FOR HOT WIRES.—There is a number of terminal lugs designed to be used without solder where the service is such that a soldered terminal would be impractical, as in the case of old style projection arc lamps, rheostat binding posts, etc. These lugs make contact with the wires by means of compression. In attaching them be certain the metal of both the wire and lug is perfectly clean. They were in common use before projector manufacturers began equipping their arc lamps with clamps to receive the wire in such form that terminals are no longer required for that service. They may still be had from supply dealers, and are suitable for connecting the wires to rheostat binding posts, although most modern rheostats will permit of the use of a soldered lug, especially if a rather hard solder be used. The soldered terminal is much the best.

GO TO WORK EACH DAY AS THOUGH IT WERE THE FIRST DAY ON A NEW JOB AND YOU HAD TO MAKE GOOD.

Lenses

THERE is a law which deals with light action with relation to its intensity at different distances from its source as follows:

"Light intensity decreases inversely as the square of the distance from its source."

This is illustrated in Fig. 27 A, and in Fig. 36 H. It is mentioned here to caution you that **this law applies to light from an open light source only,** because many have committed the blunder of applying it to the light beam between the projection lens and the screen. The law does **not** apply to light after it has been acted upon by a lens.

In Fig. 27A, A. B and C represent screens held before an open light source at different distances therefrom. Remembering that light travels in straight lines, it is readily seen that screen A would receive all the rays falling within the two black, diverging lines, and that screens B and C could only receive the relative portions as indicated. See further explanation accompanying Fig. 36 H, page 162.

OPTICAL TRAIN.—The optical train of the motion picture projector is made up of two entirely separate lens com-

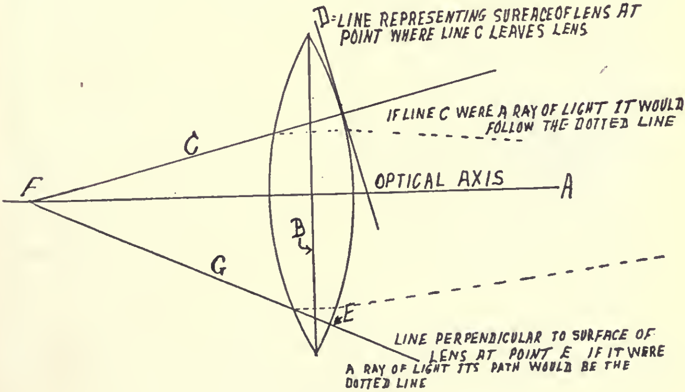


Figure 27.

binations, optically so joined that they become, in effect, a compound lens system.

THE CONDENSER AND ITS FUNCTION.—The first element of the system is the condenser, the function of which is to receive the diverging rays from the light source, refract and converge them to what is known as the "spot" at the projector aperture. Put another way, the office of the condenser of a motion picture projector is to direct upon the projector aperture the greatest possible amount of the total available light.

THE FUNCTION OF THE PROJECTION LENS.—The second element of the system is the projection lens. Its function is to receive the diverging light rays carrying the film image, and to refract and focus them at the screen in an enlarged, reversed image of the film picture.

TECHNICAL TERMS.—There are many technical terms used in connection with lenses and optics, but we believe that, insofar as concerns the projectionist, only a few are of any considerable importance.

PRINCIPAL AXIS.—The principal axis of a lens is an imaginary line which passes exactly through the center of its diameter, and is exactly perpendicular to its plane, remembering that in optics "perpendicular to" means at right angles to.

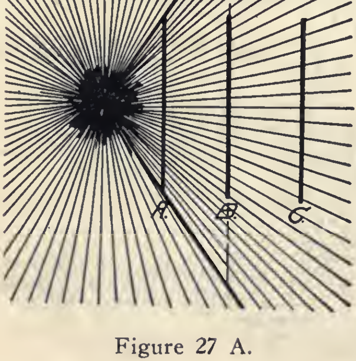


Figure 27 A.

In Fig. 27 point F is the center of curvature of the surface of the lens farthest away from it. Line F A is the principal axis of the lens, because it is perpendicular to line B, at the center of the diameter of the lens and line B is the plane of the lens. It will thus be seen that if line F A were a ray of light it would not be refracted, because it would meet both surfaces of the glass exactly at right angles, or, in optical terms, would be perpendicular to both surfaces of the lens, hence would pass straight through.

Let us also examine line C, which, too, will meet one surface of the lens, the one farthest from point F, exactly at right angles, because any line drawn from a point of curvature will be exactly perpendicular to the surface at the point it meets it. In Fig. 27 line D is intended to represent the surface of the lens exactly at the point line C meets it.

But, as a matter of fact, if line C be a ray of light it will not continue straight through as shown, but will be refracted by the first surface, because it meets the surface at an angle, and will follow the path indicated by the dotted line. Likewise line G would be perpendicular to the lens surface at E, if it were continued straight through. But it is refracted by the first surface, and refracted very much more than line C because it meets the glass at a much greater angle.

Neither line C or line G is a principal axis, because neither is perpendicular to the plane of the lens as represented by line B.

CONJUGATE FOCI.—Conjugate foci is a term having reference to two points, one being the distance of the optical center of the lens from a light source, or from an object, and the other the distance from the optical center of the lens to the point at which the rays from the light source or object are focused into an image. The conjugate foci points are shown in Fig. 30, in which object X (candle) is one point and the image, Y, the other. Altering the distance of the object from the lens automatically alters the distance of the image. If the candle (Fig. 30) be moved nearer the lens, then image Y will automatically be removed further away, and vice versa. In a projector optical train the conjugate foci points of the condenser are the light source and the image of it which is formed near the "spot," while the conjugate foci points of the projection lens are the film and the screen.

REFRACTION.—The action of lenses is based upon the following:

Light rays travel in straight lines in any transparent medium of even density, but are bent or refracted while passing from a medium of one density to a medium of another density, provided the rays enter the second medium at an angle to its surface.

It therefore follows that, glass and air being of different density, if rays of light pass from one to the other at an angle to the surface of either medium, they (the rays) will be bent, or "refracted." Concerning this, "Optic Projection," page 576 says:

"The amount of bending depends upon two conditions: (1) The greater the angle of incidence of the light, that is, the further from the perpendicular or normal that the light strikes the surface, the greater will be the bending upon entering the second medium. And this increase is not simply with the increase of the angle of incidence but proportionally greater, that is, in accordance with the law of sines. (2) The bending depends also upon the difference of density of the two transparent media. If the difference is great, the refraction will be great, and if the difference of density is small, the refraction will be proportionally small."

It is not the purpose of this work to instruct in optics, except insofar as we feel is necessary to give the projectionist a broad understanding of lens action. We do not expect to enable him to determine the refractive index of glass, but we do expect to give him a comprehensive understanding of how and why a lens refracts rays of light, and focuses light rays to an image.

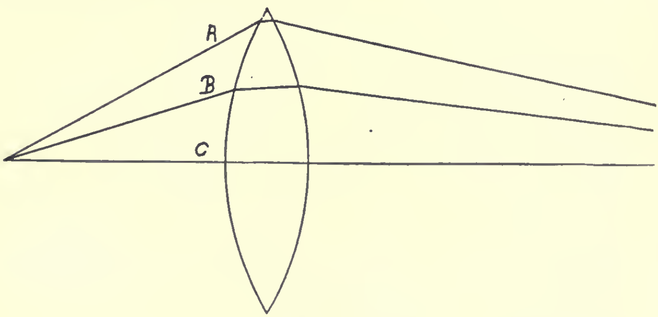


Figure 28.

In Fig. 28 we see three rays of light incident upon a simple bi-convex lens. Ray A strikes the lens surface at a comparatively heavy angle, hence is bent (refracted) at a heavy angle. Ray B strikes the surface of the lens at a less angle, hence is refracted in less amount. Ray C strikes the glass perpendicular to its surface hence is not refracted at all, but passes straight through.

Since air and glass are always the mediums for transmission of light, insofar as concerns the projectionist, and the density of glass varies but little, we may roughly assume that the amount of refraction the rays will receive from a lens will be dependent almost entirely upon the angle at which it encounters the surface of the glass, either in entering or leaving the lens.

Those who wish to know why the rays are bent under the conditions named will find the explanation in any good work on physics. It seems hardly worth the space to set forth the matter here.

ANGLE OF INCIDENCE.—The angle of incidence is the angle the entering rays makes with a line perpendicular to the surface of the medium.

ANGLE OF REFRACTION.—The angle of refraction is the angle a ray makes with a line perpendicular to the surface of the medium after leaving it.

WORKING DISTANCE.—See page 49.

EQUIVALENT FOCUS (E. F.).—A term applicable to compound lenses consisting of two or more individual elements, as in the case of the projection lens. It means that the combination will possess the same power of reduction or magnification possessed by a single, simple lens having the same focal length as the equivalent focus of the combination. For instance: If your projection lens is a 4.5 inch equivalent focus (E. F.) then it will, when working under the same conditions, project the same size picture that a single lens of 4.5 inch focus would project. Equivalent focus is of value to the projectionist in computing the focal length lens required to project a given size picture at a given distance. See page 155.

SPHERICAL ABERRATION.—Spherical aberration is that quality of a simple lens which causes it to focus rays which pass through it at varying distances from its principal axis at different distances from its optic center. The professors Gage, in their book, "Optic Projection," define it as "the unequal bending of the light rays in different zones of a lens." This we do not regard as correct as to language (although what is meant is correct enough), because naturally the rays will be bent unequally in different zones of a lens. Were this not so there could be no reduced or magnified image with parallel rays incident.

Rays passing through the outer edge of a simple uncorrected converging lens cross the principal axis of the lens at a point nearer its optic center than do rays passing through the lens nearer its principal axis. This is illustrated in Fig. 29.

CHROMATIC ABERRATION.—Avoiding a technical definition, chromatic aberration is that quality of a lens which

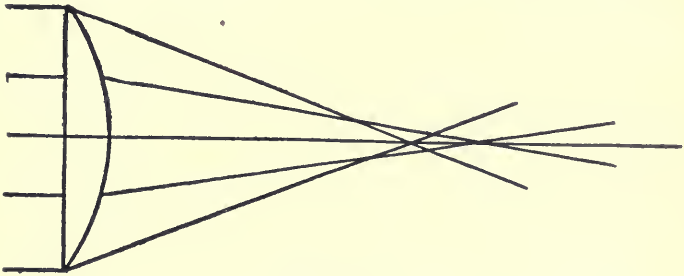


Figure 29.

causes it to separate white light more or less into its primary colors. It is a quality of simple lens action which causes it to focus different color waves at different points or distances. Different kinds of glass have different characteristics in this respect, and by combining different glasses and curves chromatic aberration is corrected. See Lens correction, page 132.

It is in order to accomplish corrections of spherical and chromatic aberration, and other faults that several lenses are used in making up a projection lens. The different kinds of glass and different kinds of lenses combine to make the desired corrections. The condenser is uncorrected, hence it has spherical and chromatic aberration, as well as all the other faults inherent in uncorrected lenses. The chromatic aberration of the condenser causes the colored light which surrounds the spot, and its spherical aberration carries some of the color down into the center of the spot, thus injuring the brilliancy of the light projected to the screen.

PROJECTION ANGLE.—See pages 20 and 255.

PROJECTION DISTANCE.—See page 38.

STANDARD FILM.—Shall be one and one-third inches wide, shall carry one picture to each four perforations, and sixteen pictures to each foot of film.

CONDENSER.—See pages 25 and 164.

LIGHT BEAM.—See page 32.

Light RAY.—See page 32.

WORKING DISTANCE.—See page 49.

THE MECHANICS OF LENSES.—In order to understand the action of light through lenses it is necessary that the student get the "viewpoint." This is a very difficult thing to do, mainly by reason of the fact that it is quite possible to view light action through lenses in more than one way, although regardless of which one of the possible views we may take the ultimate result is essentially the same.

From the optical viewpoint each tiny pin point of the surface of a lens presents an entirely separate proposition from every other pin point, because of the fact that it presents a different angle to the light, thus producing refraction slightly different from that of the point next adjoining it, and different from every other portion of the surface of the lens.

One fundamental fact the student should get firmly fixed in his mind is that:

Once a light ray has entered a lens at an angle to its surface, and has thus received its initial bending, or refraction, it will, if the glass be of even density, travel in a perfectly straight line until it reaches the opposite surface of the lens, where it re-enters the air, and in so doing receives its second bending or refraction.

We thus see that, except for the slight variation in density of glass, the action of a lens is dependent wholly upon its surfaces, which fact should impress us with the imperative necessity that lenses have surfaces which are optically true.

If a light ray enters and leaves a lens at exactly right angles to both surfaces of the glass there will be no refraction and the ray will pass straight through, but if it strikes the glass at an angle the ray will be bent or refracted.

Thus, let us assume a pin point of light located on the optical axis of a simple lens. Rays from the light source, of course, diverge in every direction. The ray meeting the lens surface at the optical axis will meet the surfaces of the glass, both entering and leaving, at precisely right angles to its surface. In optical language, the ray will be "perpendicular" to the surfaces of the lens, hence there will be no refraction.

This particular ray will pass straight through, but the surface of the lens being curved at every point, the ray which strikes the lens ⅛th or even 1/100th of an inch from the optical axis of the lens will meet the glass at a slight angle. Hence the ray will be refracted, and the amount of refraction will be partly dependent upon the distance of the light source from the lens, since the distance of the light source from the lens of course controls the angle of the rays thereto. The same is true of the ray that meets the lens half an inch from its optical axis. In this case the ray will be refracted more than the one which meets the lens nearer to its optical axis.

A very understandable illustration is found in the condenser. Suppose the arc to be a pin point of light located 3.5 inches from the surface of a 4.5 inch diameter lens. The ray which strikes the lens half an inch from its optical axis will not strike the glass at much of an angle, hence its initial refraction or bending will be slight, but the ray which strikes the lens near its outer edge will meet the glass at a heavy angle, hence its initial refraction will, by comparison, be very great. (See figure 28, page 128.)

LENS CORRECTION.—All uncorrected lenses have both spherical and chromatic aberration. By means of a combination of different kinds of glass and positive and negative curvatures it is possible to correct lenses for both spherical

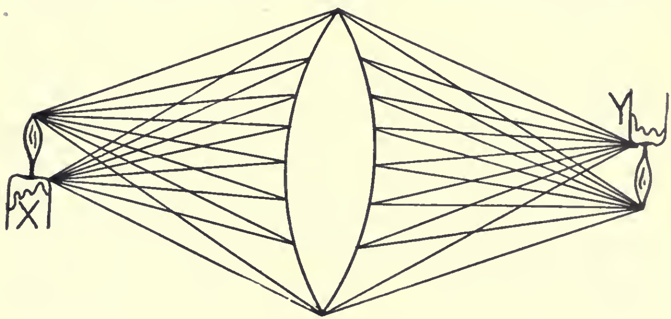


Figure 30.

and chromatic aberration. As a matter of fact, projection lenses are thus corrected. In this correction what is known as crown and flint glass are used. See Chromatic Aberration, page 130.

Those who wish further enlightenment on this matter, which has entirely to do with practical optical work, will find lengthy treatises on the subject in various optical works, which may be consulted at the public library. Also see "Optic Projection," page 581 and Fig. 324.

IMAGE FORMATION.—Assuming the lens in Fig. 30 to be free from spherical aberration, all rays emanating from any given point on light source X and striking the surface of the lens will be refracted in such manner that they will again meet at point Y, these two points being called the "conjugate foci" points of the lens.

If light source X be located nearer the surface of the lens, point Y will automatically be moved farther away from the surface of the lens, and if light source X be placed near enough to the lens, point Y will finally be lost and the rays will leave the lens in parallel, or even in diverging lines.

On the other hand, if light source X be moved farther away from the lens, point Y will automatically be brought closer

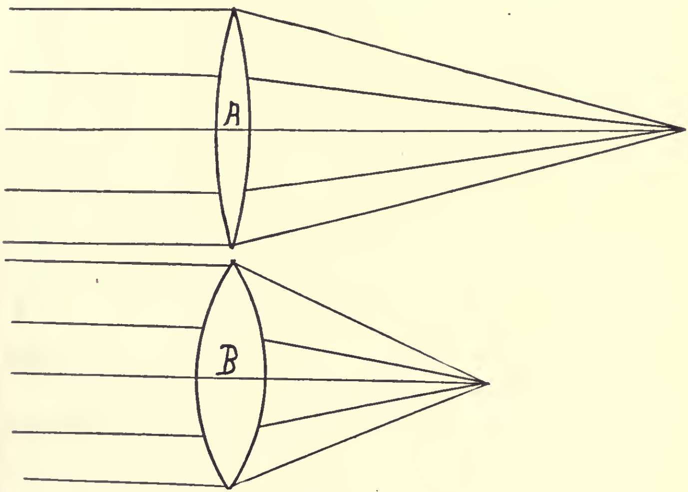


Figure 31.

to its surface. It is this law of optics which is brought into operation when the film image is focused on the screen by adjusting the projection lens—moving it nearer to or farther away from the film, which is, of course, exactly the same thing as moving the film itself nearer to or farther away from the lens. Assuming the lens shown in Fig. 30 to represent the projection lens, X to represent the film, and Y the screen, if the lens be too far from, or too close to X, then the Y conjugate foci point will not be at point Y, and the rays will not meet or focus there, in explanation of which see Fig 36D.

FOCAL LENGTH.—The focal length of a simple lens is the distance from its optical center to the image, when the image is in sharp focus and the object sufficiently distant to cause the lens to receive parallel rays of light. The focal length of a lens is determined practically entirely by the curvature of its surfaces.

In Fig. 31, we see two lenses, one of which, A, has slight curvature, while the other, B, has rather heavy curvature. By reason of its slight curvature, the refractive power of the lens shown at A is not so great as is that of the lens shown at B. It will thus be seen that the heavier the curvature of the surface of lenses of this type, the shorter is their focal length. This is by reason of the fact that the heavier the curvature the greater will be the angle at which parallel rays of light will strike the glass, both on entering and leaving the lens, hence the greater the amount of refraction the rays will receive, and the nearer the lens they will be brought to an image forming focus. The surfaces of lenses used for projection work, both condenser and objective, are always the section of the surface of a true sphere.

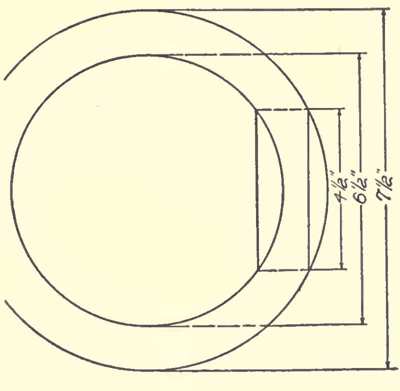


Figure 32.

HOW LENS CURVATURE IS DETERMINED. — In Fig. 32 we are enabled to see how the curvature of an ordinary lens is determined. Looking at the measurements we see that the outer circle is 7½ inches in diameter and the inner circle 6½ inches in diameter. Let us imagine the outer circle to represent the circumference of a glass ball, that we halve it and polish the flat sides of the discs of glass thus produced. We would then have two 7½ inch diameter, 7½ inch focal length plano-convex lenses.

If, on the other hand, we saw off a section 4½ inches in diameter from the surface of the ball, and polish the flat side, we will have a 4½ inch diameter 7½ inch focal length plano-convex lens. If the same thing be done with a glass ball 6½ inches in diameter the same result would be had, except that in halving the ball we would get two 6½ inch diameter, 6½ inch focal length lenses, and by cutting off a section 4½ inches in diameter we would have a 4½ inch diameter 6½ inch focal length plano-convex lens.

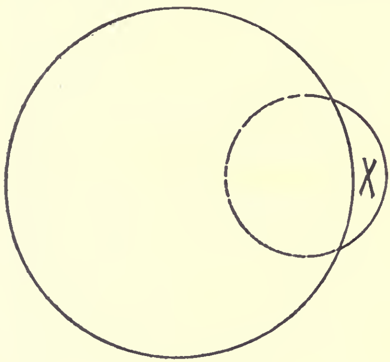


Figure 33.

It will thus be seen that with a plano-convex lens the convex surface will always have the curvature of a circle, the diameter of which is equal to the focal length of the lens. It will also be noticed that the larger the diameter of such a lens the thicker it will be.

The method of designing a meniscus lens is indicated by Fig. 33, in which the smaller circle represents the circle determining the outer or convex curvature of the lens, as in Fig. 32. But instead of a plano surface on the opposite side, as in the case of the plano-convex, the meniscus has a concave surface. We therefore determine the degree of curvature for the concave surface by means of the larger circle shown in Fig. 33.

The designing of curves for a meniscus lens is an optical problem, entirely too involved for any except a man trained in such work.

FOCUS.—At the risk of repetition we desire to impress upon the mind of the student the fact that unless the object or light source be a pin point, a lens will not focus the light beam to a pin point. A lens is presumed to form an image, and an image always has area. The matter should be viewed thus: Rays emanate from each pin point of the object, or light source. (When projecting a light source, which is exactly what the condenser does, the light source becomes an "object," within the meaning of that term as here used.) The rays from the particular pin point, and all other pin points of the object or light source, are picked up by a considerable area of the lens, or perhaps by its entire area, and the rays from each particular pin point of the object are refocused to a corresponding, though perhaps a magnified or reduced point in the image. That is what is meant by "focus." It is illustrated in Fig. 30.

A little study will enable the student projectionist to understand why he is unable to focus the condenser ray to a pin point. In the case of the condenser ray, the condenser is receiving rays from the entire area of the floor of the carbon crater, and is refocusing them to an image of the crater. By reason of the fact that the crater does not set square with the condenser (the lower part being farther away from the lens than the upper part, and the further fact that the uncorrected lenses used for condensers set up spherical aberration) the actual image of the crater will be focused over a considerable distance in the condenser ray. Only a certain portion of the crater will therefore be in sharp focus at any one point in the condenser beam. Since the crater itself has considerable area, the image will have area, hence the beam cannot be focused to a point.

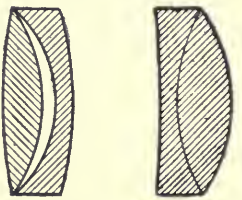


Figure 34.

PROJECTION LENS.—A projection lens is in fact a combination of four lenses, two of which are located at the end of the lens tube nearest the film. These two lenses are separated by a spacing ring by some manufacturers, but not by others, and the combination is commonly referred to as the "back factor" of the projection lens. The two other lenses located at the opposite end of the lens tube are cemented into direct contact with each other by means of Canadian Balsam, and are commonly referred to as the "front factor" of the projection lens. The front factor, usually being cemented together, will, at a superficial glance, appear to be one thick lens. As a matter of fact, the combination consists of one negative lens and one double convex lens, as indicated in Fig. 34, which shows the detail of Gundlach-Manhattan lenses.

It sometimes may happen that the balsam with which the front factor of the projection lens is cemented together will melt, thus causing the lens to have a sort of streaked appearance. Should this occur it will be necessary to send the entire lens back to the manufacturer to have the front factor recemented. It is possible to separate the lenses by heating them in hot water, but it will disturb the corrections of the lens. It is a job which can be properly done only by the manufacturer.

KEYSTONE EFFECT.—Keystone effect and its accompanying distortion cannot be removed or corrected by projection lenses, specially ground or otherwise, it being the natural result of the difference in distance the rays at the top and bottom of the light beam must travel in order to reach the screen. See page 253.

CLEANING LENSES.—It is essential to best results that the surfaces of the projection lens be kept scrupulously clean. Oil on the surface will cause very serious loss of definition in the picture, and even the faintest, almost imperceptible finger mark will do the same thing, perhaps in lesser degree. An even distribution of an accumulation of dust particles from the air may not seriously affect sharpness of focus, but it sets up additional loss of light through reflection. Hence from every viewpoint it is of great importance that the surfaces of the lenses be kept perfectly clean and highly polished.

There are several patent preparations on the market for cleaning lenses, some of which are good. We believe, however, that all the projectionist needs to keep his lenses in first class condition is half a pint of wood or denatured alcohol, diluted with half a pint of clean water. The combination fills a pint bottle, costs but a few cents, and if used economically lasts for a long time.

Nothing but a perfectly clean chamois skin, or soft, perfectly clean cotton cloths, such as old handkerchiefs, should be used for cleaning lenses.

Lenses should be washed with a cloth saturated in the alcohol solution, and then quickly polished **while still wet.** It should be a part of the daily duty of the projectionist to carefully examine the outer surfaces of his projection lenses and his condenser lenses, and to clean them if necessary. At regular periods the projection lens should be disassembled and the interior surfaces of the various lenses cleaned. In disassembling be very careful not to get the two rear lenses mixed because if they be wrongly replaced the corrections of the lens will be either ruined, or at least be so badly damaged that the lens will not give good definition. In replacing the rear combination get the side of heaviest curve toward the screen, and do not forget to replace the spacing ring, if there is one.

The front (thick) lens combination should be placed in the mount, with its surface of greatest convex toward the screen.

The guiding rule in reassembling a projection lens is to place all lenses with their greatest convex toward the screen.

While the lens is disassembled, carefully examine the interior of its barrel and if at any point the black paint has worn off so that the metal shows, retouch it with lamp black ground in Japan, thinned with turpentine. Lamp black ground in Japan may be had at any first class paint store. It is known as coach painter's black. Unless the interior of the projection lens be kept coated with non-gloss black there will be reflected light projected, which may fall outside the screen proper. Cases have been known where the interior of the lens barrel reflected so much light from the above cause that a circle of light surrounded the entire screen.

In reassembling, the lenses should be clamped snugly in their mounts, although it is advisable not to screw the ring down too tightly, remembering that in due time it must again be removed.

Concerning this matter one lens manufacturer in an instruction booklet on its lenses says: "In cleaning and assembling, first note whether the extension tube is attached to the front or rear end, so that you will replace it correctly. Clean both sides of the front combination, but do not remove it from its cell. To remove the retaining ring from the rear cell, press lightly on two sides of the ring with two fingers and unscrew it. Too much pressure will make it bind so that it will not turn. Clean inside surfaces of the two lenses of the rear combination and replace in cell. Be careful that they are seated evenly, screw up the retaining ring just tightly enough to prevent them from moving, then clean the outside surfaces. Note that the rear lens is convex on both sides, the flatter side being the outside rear surface. The retaining rings should face toward the center. Reversing the cells will disturb the correction."

To remove grease or oil from the surface of a lens use a soft rag, free from grit, moistened with a little gasoline.

Be careful when screwing the parts together to avoid crossing threads and do not screw up any joint very tightly.

Do not use a hard, sharp tool to remove retaining rings. It may slip and scratch the lens.

In reassembling Gundlach-Manhattan lenses follow Fig. 34, which is a cut supplied by that company.

REPAIRING LENSES.—Should one lens of a projection lens be broken or injured, it may be replaced, but in order to do this it is absolutely necessary that the complete lens be returned to its maker, with the broken or injured member. The broken element has no value whatever, but unless it is sent, there is danger that the focal length of the lens combination will be changed in the replacement.

Odd lenses or combinations of lenses have absolutely no value. They cannot be utilized by lens makers to build complete lenses, except at greater cost than a completely new lens. The difficulty arises in matching other lenses to the old ones. In cases where just one lens of a combination is broken the manufacturer can ascertain the exact formula for the broken lens by measuring the fragments.

LENS APERTURE AND FOCAL LENGTH.—Lenses are not made with a free aperture (diameter of free opening) greater than half their focal length. For instance, a 4-inch focal length lens could not be made with a greater working aperture than 2 inches. In practice they are not even made that large.

ORDERING LENSES.—In ordering projection lenses, give the following data: (A): Width of picture desired and distance from the screen to projector aperture. If the lens is above center of the screen appreciably the latter measurement should be from midway between top and bottom of picture. (B) Make of projector. (C) Specify lenses with or without jackets. (D) If two lenses are ordered specify as to whether you want them matched or not. (E) If matched lenses are wanted and your projectors are new, it will not be necessary to give width of aperture, but if the projectors are quite old it will be best to have exact width of aperture, measured with a micrometer caliper. This is especially important if one projector be new and the other quite old.

RANGE OF FOCAL LENGTH.—Projection lenses from 2 to 8-inch E. F. are carried in stock by manufacturers.

MATCHING LENSES.—Do not attempt to order a lens to match one you have by giving the focal length on the lens barrel. These focal length markings cannot be depended upon for close work. They are usually only approximate.

If you have a lens and want one to match it you must send the lens to the manufacturer to be measured, or else give the manufacturer the precise width of the projector aperture as measured by a micrometer caliper, the exact distance from aperture to screen and the precise width of the light upon the screen when there is no film in the projector.

Even with these precautions you cannot be certain, because an error involving the smallest fraction of an inch may result in unsatisfactory results, if the error be made at the right place. If there is a keystone, the distance from screen to aperture must be measured at the same distance from top or bottom of picture that the width of picture is measured. Better send the lens. It is the only sure way.

When lenses are purchased in pairs they are usually matched by selecting lenses from stock. Suppose two lenses are wanted to project a picture of a certain width at a certain distance. The dealer or lens maker finds by computation that this requires a 5-inch E. F. lens. He tries one and finds it gives a picture a bit too large. He tries another and another until one is just right. He then, by a process of selection through tests, finds another which gives exactly the same size picture at that distance.

Why is this, you ask? Why did not the 5-inch lens give what it was supposed to give? For the reason that lenses vary, and their markings are not accurate. A 4-inch E. F. projection lens may vary from 3.95 to 4.20 inches, according to the admission of one large lens concern. Exhibitors and projectionists should remember this when matched lenses are wanted.

NOTICE.—The Gundlach Manhattan Optical Company marks the exact actual focal length of its projection lenses in the invoice sent to purchasers. This notation is in figures and in parenthesis.

This bit of information should be carefully filed away in the projection room, because if a lens of that focal length is ordered later it will match the one you have.

LIGHT LOSS BY REFLECTION.—The Professors Gage set the losses due to reflection from the polished surface of each lens at as much as 4 to 5 per cent., or a total of 8 to 10 per cent. for each lens, or plate of glass. They further remark that if the surface be not perfectly clean, or perfectly polished, the light loss may amount to as much as 15 per cent. of the total from each surface. Some authorities place the loss even higher, giving a minimum value of 6 per cent per surface.

In this connection the following valuable data was contributed by Dr. Hermann Kellner of the Bausch & Lomb Optical Company, manufacturers of projection lenses, in the form of a paper read before the Society of Motion Picture Engineers at its meeting in Dayton, Ohio, October 12, 1920. This paper appears in the Dayton transactions of the Society:

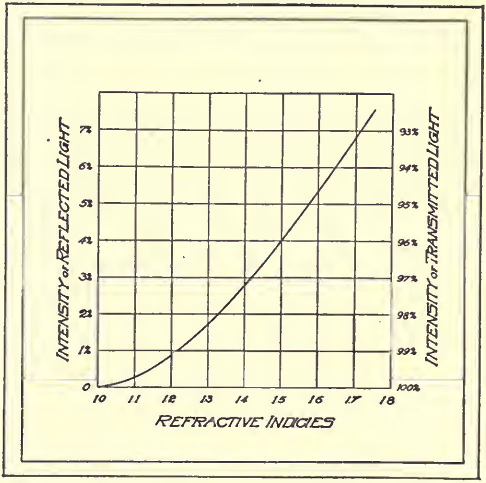


Figure 35.

"Losses of light in projection lenses may occur for two reasons:

"First, geometrical arrangement of power, distances, etc., sizes of lenses;

"Second, physical reasons, material the lenses are made of, conditions of glass surfaces, etc.

"It is the physical conditions with which we are concerned now.

"When light strikes a border surface between two optically different media, water and air, for instance, a part of the light enters the water and illuminates the bottom or the containing vessel, while another part is reflected back into the air. So is part of the sunlight which strikes a window passed into the room, while another part is reflected upon the street. The ratio of reflected to transmitted light depends upon the refractive indices of the media, as well as upon the finish of the surface.

"The greater the difference in refractive index, the more light is reflected and the less light is transmitted. If we have two horizontal surfaces, side by side, one formed by water, the other of glass, and observe the amount of sunlight reflected, we will find the glass surface to be a more efficient reflector than the water surface, and at the same time the illumination inside the water will be greater than inside the glass.

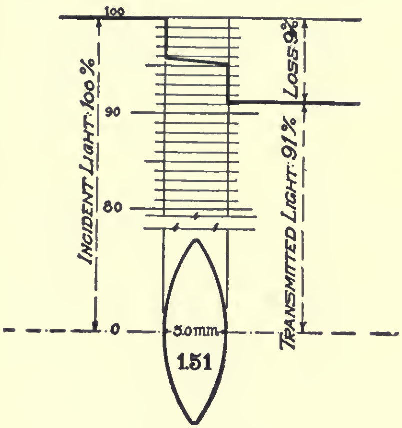


Figure 36.

Shows the curves for the loss of light in a double convex lens of refractive index 1.51 at and between the surfaces.

"The amount of reflected light also changes with the angle of incidence. The more nearly perpendicular the light source is to a surface, the less the amount of light reflected. From this it is evident that the conditions for passing the greatest amount of light become most favorable when the refractive index is as low and the angle of incidence as small as possible. Remembering that the angle of incidence is the angle between the direction of the ray of light and the perpendicular at the point of incident, we see that the nearer the ray of light is perpendicular at the point of incidence the smaller is the angle of incidence.

"The action of a lens depends on the refractive index of the material it is made of. To get any lens action at all, the refractive index has to be greater than that of air, the value of which is set at 1.00. We therefore shall always have a certain loss of light when it passes through a lens surface. The amount of this loss is determined by means of a formula which was derived by Fresnel, the famous French mathematician and optician. He found for perpendicular incidence the following equation:

$$I - I^1 = \frac{(n-1)}{(n+1)}2$$

Wherein I is the amount of light falling upon the surface; I^1 the amount of light transmitted by the surface; and n the refractive index of the medium. The difference I — I^1 is the loss of light at the refracting surface. The curve in Fig. 35 shows, for refractive indices varying from 1.0 to 1.8, the intensities of the reflected and transmitted light.

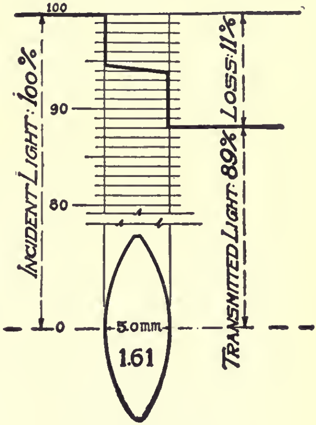


Figure 36A.

Shows the curves for the loss of light in a double convex lens of refractive index 1.61, at and between the surfaces.

"The amount of variation in loss of light with variation in the angle of incidence is set forth in the following table, in which it is assumed that the light is unpolarized, an assumption which satisfactorily represents practical conditions:

Table 6A

Angle of Incidence Degrees	Per Cent. Crown 1.51	Per Cent. Flint 1.61
0	Loss 4.13	Loss 5.46
30	" 4.28	" 5.64
60	" 9.08	" 10.69
70	" 17.29	" 18.97
80	" 38.92	" 40.30
90	" 100.00	" 100.00

Caution Note.—"Crown 1.51" and "Flint 1.61" refer to refractive index of those glasses.

"The refractive indices of the glasses used in projection lenses, which are crown and flint, vary from about 1.51 to 1.61.

"From table 6A we learn that the loss of light per surface for perpendicular incidence is 4.13 per cent. for crown **glass** the refractive indice of which is 1.51. Whereas for flint glass the refractive indice of which is 1.61 the loss amounts to 5.46 per cent.

"The angle under which light rays strike the surfaces of a projection lens varies from 0° to about 30°, and fortunately for the simplicity of this discussion the variation of the loss within these angles is negligible, as may be seen in the table. We may therefore say that the loss of light per surface on a crown glass lens amounts to 4.2 per cent., and on a flint glass lens it is 5.5 per cent.

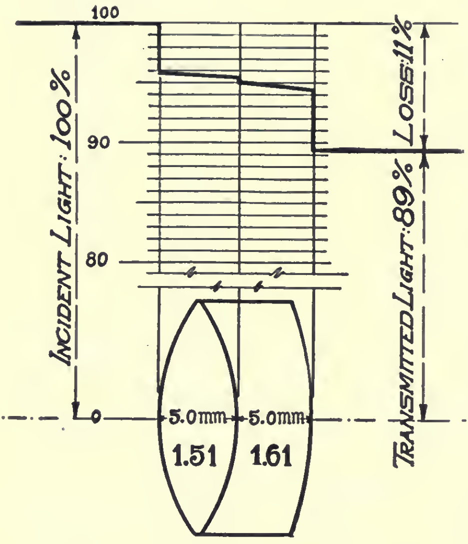


Figure 36B.

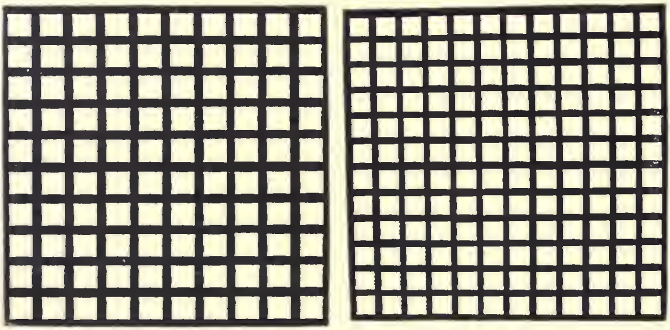
Shows the curve for the loss of light in a cemented doublet consisting of a lens with refractive index 1.51 and another lens with a refractive index 1.61 at and between the surfaces.

"The refractive index of Canadian Balsam is approximately equal to that of crown glass, therefore if a crown lens of 1.51 and a flint lens of 1.61 be cemented together, the loss by reflection at a cemented surface is very much smaller than at surfaces bordering on air. The reflective index of Canadian Balsam being practically the same as that of crown glass, no loss is incurred in the passage from the crown glass lens into the layer of balsam, while between the balsam and the flint glass the difference amounts to only 0.1 per cent., which means the total loss is almost negligible.

"For a number of glass surfaces in air, each having about the same loss by reflection, the total loss may be arrived at by using the compound interest formula. If the loss, p, for one surface is represented as a fraction of the initial intensity, the loss for k surfaces will be $1-(1-p)k$.

"The loss by absorption depends on the nature of the glass and on the thickness of the lenses. Good crown glass will not absorb more than 0.5 to 1 per cent. per centimeter thickness, while flint glass of 1.61 refractive index will run a little higher, from 1 to 1.5 per cent. per centimeter.

"The lighter varieties of flint glass, of indices between 1.54 and 1.61, have absorptions between these limits, while



A B

Figure 36C.

the absorption of poor glasses runs as high as 3 and 4 per cent. per centimeter.

"Considering a crown glass lens of an average of 5 mm. thickness, the losses by reflection and absorption total up as follows: At first surface 4.2 per cent., by absorption .5 per cent., at last surface 4 per cent., or a total of about 9 per cent. per lens.

"With a flint lens of 1.61 refractive index we obtain the following data: Loss at first surface 5.5 per cent., by absorption .5 per cent., at last surface 5.2 per cent., or a total of about 11 per cent. per lens.

"For a cemented lens consisting of cemented crown and flint elements we find 4.2 per cent., .5 per cent., .1 per cent., 1 per cent., 5.2 per cent., or again, a total of about 11 per cent. Figures 36, 36A and 36B represent these conditions graphically.

"In this way it is easy to form an opinion as to the losses by reflection and absorption in any combination. In general it is safe in forming an estimate to assume the total per single lens, or per combination of cemented lenses, as they occur in projection lenses, at about 10 per cent.

"If the workmanship and material are approximately the same, and no difference exists in the geometrical arrangement, diaphragming, etc., of the lenses, the amount of light passed through is very nearly the same in all lenses that have the same number of reflecting surfaces.

RESULT OF DIRTY LENSES.—"A very important factor in the performance of a lens is the condition of its surfaces. Scummy and dust-covered lenses give gray pictures, with no contrast, exactly in the same way that photo lenses will not take good pictures if dispersed light from finger-marks on

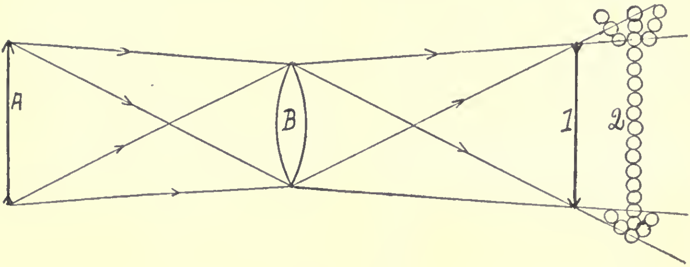


Figure 36D.

the lens is allowed to reach the plates. It is therefore of the utmost importance that in comparative tests the lenses be perfectly clean.

"I may mention briefly the fact that there exists a condition of lens surfaces which is helpful in the way of reducing the amount of reflected light and increasing the amount of transmitted light. Such surfaces have an iridescent appearance caused by chemical action. It had been discovered accidentally in process studios that such lenses allow shorter exposures. Upon investigation it was found that the amount of transmitted light actually had been increased. Unfortunately such action takes place for the most part on glasses which have comparatively great absorption co-efficients, and not generally used for projection lenses. Any thought of reducing losses in projection lenses by these means will probably have to be dismissed, although the amount of loss by such treatment can be reduced by as much as 50 per cent.

"In conclusion I may say that all the statements made above are borne out by practical tests, not only in comparatively simple combinations like projection lenses, but also

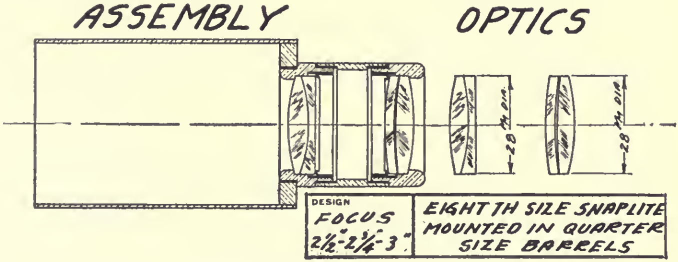
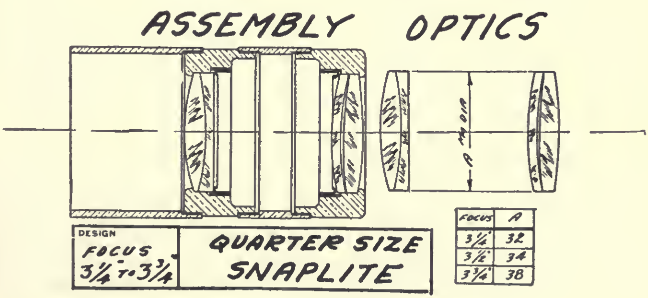


Figure 36E.

in the most complicated apparatus like range finders, submarine periscopes, etc."

(**Note**—We have made a few changes in Dr. Kellner's language to lessen his technicality for our readers, but his meaning has in no degree been altered.—Author.)

PROJECTION LENS DIAMETER.—For reasons which will be explained in later pages, the diameter of the projection lens is a matter of large importance. Under conditions where the amperage is high and the working distance of the projection lens long a small diameter objective means heavy loss in efficiency—waste of light—as well as uneven



FOCUS	A
3¼	32
3½	34
3¾	38

Figure 36EE.

illumination of the screen, with consequent loss in "depth" in the picture itself. On the other hand, it may be accepted as fact that the small diameter objective makes for improvement of the picture, gives much greater depth of focus—an important matter indeed where there is considerable angle to the projection—and in general sets up a better condition with regard to the revolving shutter. It follows that

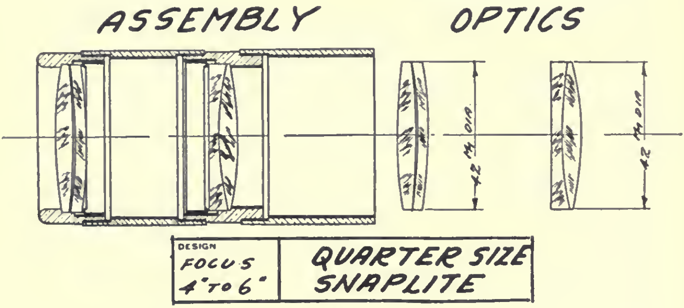


Figure 36F.

any diameter greater than that necessary to accommodate the actual picture bearing light beam is not only undesirable, but distinctly bad.

We might, however, here repeat that it is impractical to make projection lenses of greater free diameter than half the focal length (E. F.) of the lens. This is a limitation which often causes a bad condition, especially in the shorter focal length lenses because, except in the case of very short E. F. lenses, only two diameters are made in practice. Whether it is practical to make all projection lenses up to 5-inch with a free diameter equal to half the E. F. of the lens or not, we do not know. However, if it can be done without sacrificing any valuable quality of the lens it certainly should be done.

DISTORTION.—Projectionists should carefully test their projection lenses for distortion. This may readily be done. First secure a perfectly flat piece of mica, commonly known as isinglass, three or four inches in length. Trim it to the exact width of a film and then, using a coarse needle, scratch straight lines on the surface of the mica, checkerboard fashion, as per Fig. 36C.

Having done this, place the mica over the projector aperture and close the film gate, being careful that the mica lies perfectly flat over the aperture, just as the film would lie. Next, raise the fire shutter and project the lines on the surface of the mica to the screen, and with a tightly stretched cord, test the lines on the screen to see that they are perfectly straight. At A, Fig. 36C, the lines are straight, hence there is no distortion. At B there is what is known as "barrel distortion," which amounts to a curvature of the lines. The lens which projects B is not a good lens, whereas the lens which projects A is perfect, insofar as has to do with distortion.

CAUTION.—Lines on the mica need not be perfectly square with each other, but each line must be perfectly straight.

FOCUSING.—The objective must focus all rays of light emanating from a given point of the film to a corresponding, though magnified, point on the screen.

As has already been set forth, the film represents one conjugate foci point of the objective and the screen the other. As you all know, if the distance of the objective from the film be in the slightest degree altered by means of the focusing screw, the definition of the picture on the screen is altered. The reason for this is diagrammatically represented in Fig. 36D.

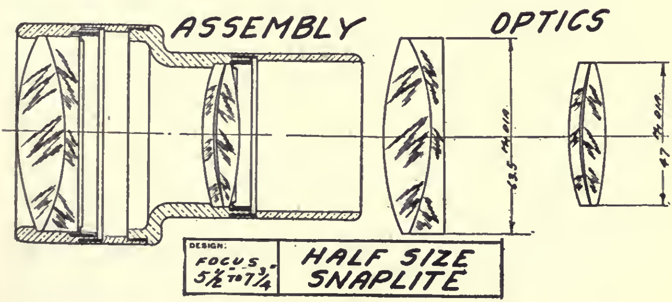


Figure 36FF.

Here A is the film, B the objective, and 2 the screen position, with the picture out of focus because of the fact that lens B is too far from film A. The rays emanating from points in film A are thus focused at 1 instead of at 2. Between B and 1 the rays converge until they finally meet at

1, but having met at 1 they cross and continue in straight lines, diverging, so that at position 2 each pin point of the film is represented by a bundle of rays, or a circular spot of light. Now, if we move lens B just a little closer to film A, the point of focus will then be at 2, instead of at 1. A study of this diagram should inform the projectionist as to

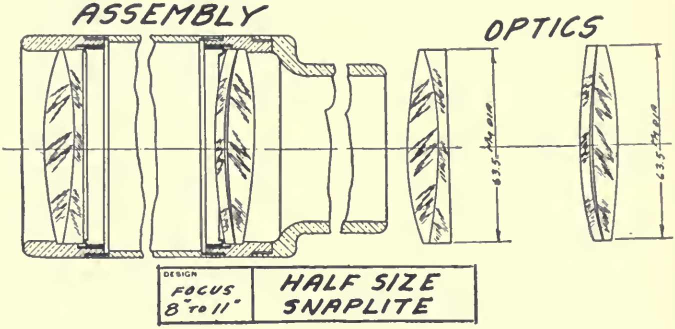


Figure 36FFF.

exactly what takes places when he focuses the picture on the screen.

"DOCTORING" LENSES.—The author has often been asked this question: "Can the E. F. of a lens be altered by shortening or lengthening its barrel in such a way that the distance between the back and front factor will be changed"?

This question must be answered both yes and no. The thing may be done, but only at the expense of ruining the lens, insofar as concerns its ability to do high class work.

PROJECTION LENS AND PICTURE SIZE.—The question is often asked, "Can a given projection lens be used to project a picture at different distances"? The answer is, yes.

But the same objective will not project the same size picture at different distances.

If the distance be made less, the picture will be smaller, and vice versa. Changing the distance of projection will also alter the working distance of the lens—distance from back factor to film. The shorter the distance between the lens and the screen the further the lens must be from the film, and vice versa.

The light beam diverges on its way from the projection lens to the screen. It is easy to figure how much change in size of picture will be accomplished by moving the screen a given distance nearer to or further away from given lens, since the divergence of the ray emanating from any given projection lens is a fixed quantity, and does not alter. See "Same Lens, Different Distance," page 154.

MEASURING LENSES.—It is not only desirable, but essential that the projectionist understand how to determine the focal length of the various lenses he is called upon to handle, with at least a reasonable degree of accuracy.

Condenser lenses, being uncorrected and containing considerable spherical aberration, cannot be measured with any great degree of accuracy by following method but the focal length of plano-convex condenser lenses may nevertheless be obtained with sufficient accuracy for practical purposes. Select a room with only one window, or else darken all the windows in a room but one, leaving this one open. On the wall opposite this window pin a sheet of white writing paper. Hold the lens to be measured in front of the paper screen thus established, with its flat side toward the screen, and carefully focus some **distant** object, such as a building or tree, on the paper screen. Be careful to hold the lens as nearly as possible square with the screen. Having focused the object selected as sharply as possible, **measure the exact distance from the flat side of the lens to the screen, after which reverse the lens so that its curved side is toward the screen, focus the same object and again measure the distance from the flat side of the lens to the screen. Add these two measurements together and divide their sum by two.**

This result will be near enough to focal length of the lens for practical purposes.

CAUTION.—In the foregoing it is essential to accuracy that the object focused be not less than 100 feet away, because of the fact that the focal length of the lens is the distance from its optical center at which it will focus parallel rays of light, and with less than 100 feet the rays entering the lens from a point on any object cannot be said to be parallel.

It is, however, possible to secure fairly accurate results by focusing an object which is only 50 feet away, and no great error will result even if the object fixed be only 15 or 20 feet away. But always focus an object 100 or more feet away if it is possible to do so.

For example, suppose the measurement with the flat side of the lens to the screen to be 6 inches, and the second measurement, with the curved surface toward the screen, 7 inches. Then, $6+7=13$, and $13\div2=6\frac{1}{2}$, hence the focal length of the lens is 6½ inches.

A bi-convex condenser lens may be measured the same as the plano-convex, except that a single focusing is sufficient. The measurement should be from the center of the lens to the screen.

The Meniscus bi-convex cannot be measured in the same manner as a plano-convex, because its optical center lies outside the lens.

The motion picture or stereopticon projection lens has these two distinct measurements: (1) the "working distance," which is the distance from the object (film or slide) to the first surface of the first factor of the lens when the image on the screen is in sharp focus, and (2) the "equivalent focus" (E. F.), which is one-fourth the distance from an object to its image when the object is focused by the lens being measured and the image and object are of the same size.

The working distance of the motion picture projection lens is of great importance to the projectionist, in that it has directly to do with necessary lens diameter, as will be set forth in figure 47, page 182.

The equivalent focus of the motion picture projection lens is the factor used in ordering lenses to project a given size picture at a given distance.

MEASURING WORKING DISTANCE.—To measure the working distance of a projection lens, place it in the projector, thread in a film and focus the picture sharply on the screen. Remove the film, and running a rule through the projector aperture, measure the distance from the aperture plate (film plane) to the first surface of the projection lens. This measurement will be the "working distance" of the lens, wrongly referred to as the "back focus." See "Back Focus," page 21.

MEASURING EQUIVALENT FOCUS.—The equivalent focus (E. F.) of a projection lens may be measured accurately as follows: Remove the projector mechanism and in the position occupied normally by the projector aperture, mount a sheet of metal in which an opening about .75 of an inch square has been cut. Next support the lens to be measured at a distance about twice its supposed E. F. on what would be the screen side of the aforesaid opening. Then, with the light projected through the opening in the usual way, hold a small screen, preferably of a dull black or very dark non-gloss color on the screen side of the lens. Move lens and screen until the image of the opening on the screen is precisely the same size as the opening itself, whereupon one-fourth the distance from aperture to screen is the exact E. F. of the lens.

To obtain this measurement properly what is known as an "optical bench" is necessary. We do not submit it as having much actual value to the projectionist, but merely for the sake of completeness.

TO MEASURE ANY LENS.—The following method of lens measurement was supplied by John Griffith. It may be used to measure the focal length of any simple lens, such as a plano-convex, bi-convex or meniscus, or it may be used to measure the E. F. of compound lenses, such as projection lenses.

To apply it, two things are necessary. The EXACT distance lens to screen, and a stereo slide on which is an opaque mark precisely .5 of an inch in length.

As to the slide, it may well form a permanent part of the projectionist's tool outfit. It may be made in several ways, the easiest of which is to cut a piece of thin metal precisely .5 of an inch in length, binding the same up between two cover glasses.

Another way is to make a scratch mark on a cover glass. A third way is to cut a slit in a metal slide, the latter being, of course, harder to make, but once it is finished it is in the nature of a permanent tool. However you may choose to make your test slide, be certain the mark is **exactly** one-half inch long, running, of course, horizontal—lengthwise on the slide.

Next it is necessary to measure the exact distance from the lens to that part of the screen to which the line will be projected, the latter because of the fact that under some conditions there is a decided difference in distance from lens to different parts of the screen, also a difference in length of the projected line. This measurement must be reduced to inches. We would suggest that the distance from screen to inside wall of projection room at a point midway of the vertical height of the lens port be made a permanent part of the projection room records. It will then be a simple matter to add to that measurement the distance from that point to the lens.

Having the distance measurement and slide, project the latter to the screen with the lens to be measured (a condenser lens may be used for a projection lens, hence you can measure condenser lenses by this method) and measure the exact length of the projected line on the screen. The rule is:

As many times as .5 is contained times into the length of the projected line, measured in inches, the focal length of the lens, if it be a simple lens, or the E. F. of the lens, if it be a compound lens, such as a projection lens, will be contained into the distance of projection (lens to screen) measured in inches.

For example: The projected line, or mark, is found to measure 7 feet 8.3 inches, or 92.3 inches. The distance from the lens to the screen (distance of projection) is 100 feet, or 1,200 inches. We then have 92.3÷.5=184.6 (dividing by .5, or ½, is exactly the same as multiplying by 2) and 1200÷184.6=6.5 plus a small fraction. Therefore our lens is a trifle over 6.5 inch focal length, if a condenser lens, and a bit more than 6.5 E. F., if a projection lens.

EQUIVALENT FOCUS AND PICTURE SIZE.—The width of picture any projection lens will project at a given distance is dependent upon the E. F. of the lens. The shorter the E. F. of the lens the wider the picture it will give at a given distance of projection, thus: A 4 inch E. F. projection lens will project a much wider picture at sixty feet than will a 6 inch E. F. lens.

SAME LENS, DIFFERENT DISTANCE.—The same projection lens may be used to project at different distances, but the resultant picture will vary in size directly as the distance of projection. If the size of the picture a lens projects at a given distance is known, the size it will project at any other distance may be computed, thus:

Suppose a lens projects a sixteen foot picture at seventy feet. Reducing the size (width is always meant when picture "size" is named with only one dimension given) to inches, we find the picture to be 16x12=192 inches wide. Since the distance to the lens is 70 feet, it follows that the ray from the lens spreads 192÷70=2.742857 inches per foot. We have then only to multiply any desired distance of projection by 2.742857 to know precisely what size picture that lens will give at that distance.

CALCULATING NECESSARY E. F. FOR PICTURE SIZE.—To compute the required E. F. of lens to project a picture of given size (width) at a given distance, proceed as follows:

Measure the width of aperture of your projector accurately (if it is a stereopticon lens, then the standard slide mat width, 3 inches, is used) by means of an inside caliper, though if the projector be of late model we may take the aperture width at .90625 (29/32) of an inch with assurance of pretty close accuracy. Next measure the exact distance from the center of the lens barrel to the screen. Multiply the distance from the lens to the screen, in feet, by the width of the aperture, in fractions of an inch, and divide the result by the width of the picture you desire, in feet.

The result will be the E. F. of the lens required to project a picture that width. It will be as close to it as you or any one else can get by figuring. If the lens itself is accurate as to E. F., the result also will be accurate.

For instance: Suppose we desire a fifteen foot picture at sixty feet. The projector aperture is found to be .90625 (29/32) of an inch wide—the new standard. We first multiply the distance from the screen, in feet, by the width of the aperture, .90625, which gives us 54.3750. Dividing this by the width of the desired picture in feet we get 3.625. We would therefore require a lens of 3.625 inches E. F. to project a picture exactly 15 feet wide at exactly 60 feet.

It would probably be impossible to find a lens marked exactly this focal length. The most practical method is to determine the width of the picture you want and the exact distance from the lens to the screen, supplying this data to the lens dealer. He will probably be able to select a lens from his stock which will meet your requirement.

The stereopticon lens is figured in exactly the same way, except that instead of measuring the aperture width we accept 3 inches as the standard slide mat width—the slide mat being, in this case, the aperture.

For the benefit of our readers we append the formula by means of which certain other factors may be figured:

The size of the image which a lens of given E. F. will project at a given distance may be found by multiplying the difference between the distance lens to screen and the focal length of the projection lens (E. F.) by the width of the aperture, and dividing the product by the E F. of the lens. For example, let L equal the projection distance, 40 feet (480 inches); S the slide mat (3 inches), and F the E. F. of the lens, which we will assume to be 12 inches. We then have the formula $d = \frac{S\ (L-F)}{F}$ in which d is the width of the image in feet. Substituting for the letters their known value we have: $d = \frac{3\ (480-12)}{12} = 117$ inches or 9.75 feet; that being the width of a picture a 12-inch E. F. stereopticon lens will project at 40 feet, provided always that the slide mat be exactly 3 inches wide. If, however, the mat be more or less then 3 inches wide, then the picture will be more or less than 9.75 feet wide. The image size a motion picture projection lens would give at a given distance may be figured in the same way, using the exact width of the projector aperture instead of the slide mat width.

If we know the size of the image, the width of the aperture and the E. F. of the projection lens, we may figure the distance to the screen as follows:

$$L = \frac{F\ (d+S)}{S}$$

Suppose, for instance, we have a 12-inch E. F. stereopticon projection lens, and want a picture 117 inches wide. Substituting figures for the above formula we have

$$L = \frac{12\ (117+3)}{3} = 480 \text{ inches or } 40 \text{ feet.}$$

We would therefore be obliged to place the screen 40 feet from the lens in order to get out the 117-inch picture desired.

LENS QUALITY.—In the past the author has advised the installation of high grade projection lenses, meaning by "high grade" an expensive, highly corrected lens. We still believe firmly in high quality lenses, but are convinced that some of the manufacturers of lenses in the United States are now producing projection lenses quite good enough for all practical purposes, insofar as quality be concerned. The mountings of these lenses are excellent and the resultant image is very good indeed. With regard to anastigmat projection lenses, we believe they are only desirable in comparatively short focal length lenses. An anastigmat projection lens of long or even moderately long focal length does not seem to present any particular advantage.

All projection lens manufacturers of prominence were invited to submit such data as would be of benefit to the users of this book. **The Koll-Morgan Optical Company,** Brooklyn, New York, submitted the excellent data found in Figs. 36E to 36FFF. From these excellent drawings all necessary data may be had.

Under "Assembly" the lenses are shown mounted and under "Optics" we see the lenses of each lens unmounted, totogether with the dimensions in millimeters. It will be observed that the Snaplite lenses have five diameters, and that they range from 2.5 to 11-inch E. F. They are very well mounted and by comparison with some other makes of projection lenses are very highly corrected. They have the approval and indorsement of the Projection Department of Moving Picture World and of the author of this book.

BAUSCH & LOMB LENSES.—The Bausch & Lomb Optical Company, Rochester, New York, manufactures projection lenses. The company supplied very complete data concerning same. The Bausch & Lomb lenses we have found to be highly corrected, well made and well mounted. They are cordially commended for all conditions to which their diameters are suited. The illustrations show clearly the assemblage of lenses and their relation to each other, while the tabulated data gives all necessary information as to both outside and free diameter.

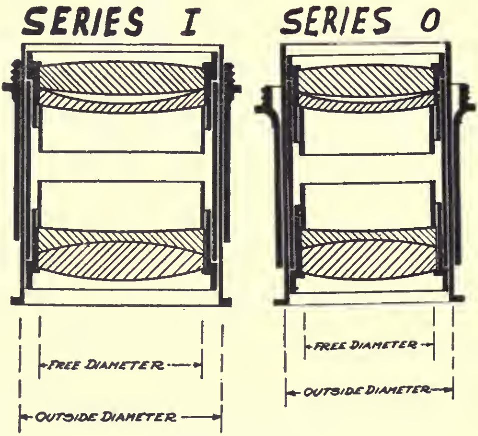


Figure 36G.

B. & L. Lenses—Exactly one-half size of actual lens.

It will be noticed that in series O and I lenses of the same E. F. may be had in two different diameters. We could hardly imagine the condition where the O diameter would be better, unless it be in the case of a heavy angle projection which compelled great depth of focus.

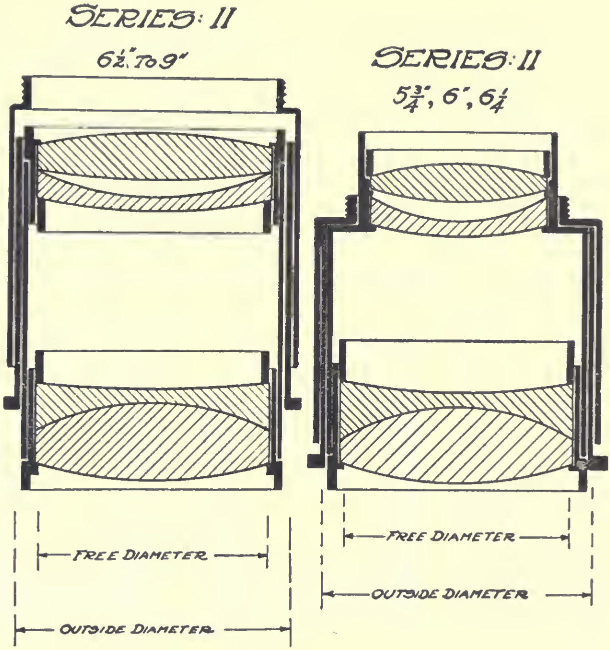


Figure 36GG.

B. and L. lenses, series 11, exactly one-half size of actual lens.

LENS TABLES OF NO PRACTICAL VALUE.—Nearly all lens and projector manufacturers put out lens tables purporting to give the size of image a lens of given E. F. will project at a given distance. We did not incorporate these tables in this work because we do not regard them as having any practical value. In the case of the stereopticon, slide mat widths vary so much that the results from such tables are little more than guesswork. In the case of the motion picture the average exhibitor or projectionist wants a picture of exactly the size he has decided upon, at an exactly predetermined distance, and for such accuracy he cannot rely upon tables. Hence the tables are not, we feel, a desirable thing.

Note: To change mm. measurements to inches multiply same by .03937.

SERIES 0.

No.	E.F.	Outside Diam. mm.	Inside Diam. mm.
1	4"	38.0	36.0
2	4¼"	"	"
3	4½"	"	"
4	4¾"	"	"
5	5"	"	"
6	5¼"	"	"
7	5½"	"	"
8	5¾"	"	"
9	6"	"	"

SERIES I.

No.	E.F.	Outside Diam. mm.	Inside Diam. mm.
10	4"	46.0	44.0
11	4¼"	"	"
12	4½"	"	"
13	4¾"	"	"
14	5"	"	"
15	5¼"	"	"
16	5½"	"	"
17	5¾"	"	"
18	6"	"	"
19	6¼"	"	"
20	6½"	"	"
21	6¾"	"	"
22	7"	"	"
23	7½"	"	"
24	8"	"	"

SERIES II.

		Front Combination		Back Combination	
No.	E.F.	Diameter. Outside	Diameter Inside	Diameter Outside	Diameter Inside
40	5¾"	64.0	62.0	49.0	47.0
41	6"	"	"	"	"
42	6¼"	"	"	"	"
43	6½"	"	"	64.0	62.0
44	6¾"	"	"	"	"
45	7"	"	"	"	"
47	7½"	"	"	"	"
49	8"	"	"	"	"
51	8½"	"	"	"	"
53	9"	"	"	"	"

Dimensions of Bausch & Lomb Motion Picture Lenses, compiled for F. H. Richardson.

THE MAN WHO GETS AHEAD IS THE MAN WHO REALIZES HOW VERY LITTLE HE KNOWS COMPARED WITH WHAT THERE IS TO KNOW.

Practical Projection Optics

THE optical system or optical train of the motion picture projector is made up of two entirely separate elements, or lens systems, which are joined together in such a way that one system (the projection lens) receives at one of its conjugate foci points the magnified and more or less out of focus image of the light source projected by the other system, the condenser.

The optical train of the projector consists of the condenser, (A) the office of which is to pick up as great a number as possible of the diverging rays from the light source, refract them into converging rays and concentrate them into what is known as the "spot" at the aperture of the projector, and (B) the projection lens, the office of which is to pick up the film image illuminated by the concentrated rays from the condenser and project it to a focused image upon the screen.

The joining of these two optical systems is no difficult matter if we disregard the item efficiency, but to join them in such way that they will work together with the greatest possible degree of efficiency is somewhat intricate, and in some conditions met with an almost impossible problem. Yet, unless the two lens systems are made to work together with the least possible loss, the waste in light, which means waste in electric power, may and probably will be a very serious matter, indeed.

We do not believe the optical system of the modern projector can be judged by ordinary optical standards, because of the fact that the conditions under which the lenses must work are themselves, in almost every particular, highly abnormal. In the case of the condenser the heat is excessive under any condition, and when the amperage mounts to 80, 90, 100, and even in some extreme cases higher, a condition is set up which calls for special treatment. In the case of the projection lens, it may, under some conditions, receive along with the film image it is to project to the screen, a more or less in focus image of the floor of the electric crater, or Mazda filament projected by the condenser system, and unless the projectionist very thoroughly understands his business it is more than likely also to receive only a portion of the light passing through the aperture, which means an unevenly illuminated image on the screen, and in addition to all this it will receive more or less stray light reflected from the edge of the aperture. Nor is this all the story of the difficulties of the motion picture projection lens, because due to manufacturing limitations, and the further fact that it must work in conjunction with the revolving shutter, its diameter is necessarily limited. Its diameter is also, to an extent, limited by the further fact that too-large diameter makes for lack of depth of focus in the screen image, which latter is a very important item indeed, if the projection lens be considerably above, or to one side of the center of the screen.

In the following we shall do our best to convey a clear understanding of practical projection optics, which is, we can assure you, no easy task.

The collector lens element of the condenser (collector lens is the one next the arc) must pick up the light emanating from the light source, which approaches the lens in diverging rays, see Fig. 36H.

THE LAW OF LIGHT.—Light diminishes in intensity as we recede from the source of light. If the luminous source be a point, then the intensity diminishes as the square of the distance increases. If we call the quantity or amount of light received by a certain given area at the distance of one foot 12 C. P., then at a distance of 2 feet its intensity would be ¼th of 12, or 3 C. P., and at a distance of 3 feet it would be 1/9th of 12, and at a distance of 10 feet it would be 1/100th of 12, and so on. This is the true meaning of the law, which reads:

With an open light source, light intensity varies inversely as the square of the distance from its source.

This law has its base in the fact that light is propagated, or travels in straight lines, and naturally those lines are diverging—separate from each other as they go forward. You may prove the law as follows: Place a light source, which may be an incandescent globe, though the law holds strictly true only with point light sources, at a distance of nine feet from a white wall. Hold a cardboard six inches square at a distance of exactly 2.25 feet from the light source, which is one-fourth the distance from light to screen, and you will find the area of the shadow of the cardboard which is cast upon the wall to be sixteen times that of the cardboard itself. It therefore follows that the amount of light falling upon one square inch of the cardboard would be sixteen times as much as would be the light falling upon a similar area of a screen located four times as far away from the light source. The operation of this law and the practical effect of distance of crater from face of collector lens is very clearly shown in Fig. 36H, in which F is an ordinary 4½ inch diameter plano-convex collector lens, having a free opening of 4¼ inches, its face located 2½ inches from the center of the crater floor.

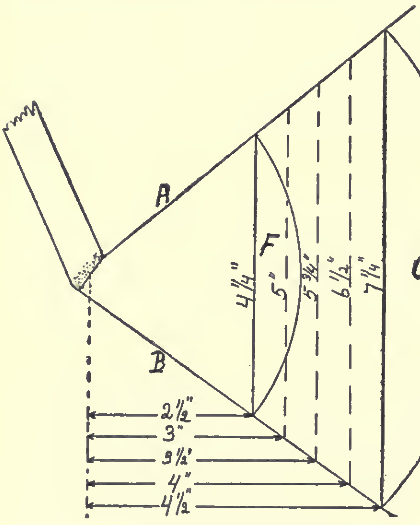


Figure 36H.

With the crater thus established, it requires no unusual power of discernment to understand that the lens will receive all light rays within the space bounded by lines A—B. That much may be very readily understood.

Remembering that once the light rays have left the source (crater floor) they travel in absolutely straight lines to infinity, it is readily seen that if we move lens F back to the position occupied by lens C it cannot and will not receive as great an amount of light as it did in the first position. In fact we believe that even the most obtuse will not dispute the proposition that a lens in position C, Fig. 36H, must of necessity have the diameter shown (7¼ inches) in order to receive as great an amount of light as is received by the 4¼ inch lens opening in position F.

The perpendicular dotted lines represent the faces of lenses at different distances from the center of the crater as shown, and the diameter each lens would have to be in order to have light collecting power equal to the 4¼ inch lens in position F is also given. It will be observed that at 3 inches a 5 inch diameter lens would be required, and at 3½ and 4 inches, a 5¼ and 6½ inch lens would be required. We believe this diagram will be rather startling to some projectionists who have paid no especial attention to the distance of their crater from the lens, and who have given no study to the practical operation of the law we have so often quoted in the Projection Department of Moving Picture World, which is again quoted at the beginning of this subject.

With the foregoing in view the importance of getting the light source as near the collector lens as possible is clearly seen, since, due to reasons which will be hereinafter explained, the diameter of the condenser lens is limited.

CAUTION.—In the foregoing connection let it be clearly understood, we do not mean that if the arc be retarded a given distance further away from a collecting lens of a given diameter the light loss would be as great as might be inferred from an examination of diagram, Fig. 36H. Fig. 36H is absolutely correct, but the fact remains that about 63 per cent. of the light is concentrated upon 50 per cent. of the area of the center of the collector lens, hence we could retard the arc a sufficient distance to equal a loss of 50 per cent. of the area of the collector lens and yet only lose about 37 per cent. of the light.

To enter into a detailed explanation of the reasons of this would not, we believe, be wise because the matter is largely one of geometry and would be very difficult for the mind of the average man to grasp. However, let it be clearly understood that the concentration of 63 per cent. of the light into 50 per cent. of the area of the collector lens in no wise impairs the correctness of the proposition set forth in Fig. 36H. It does, however, operate to modify the amount of loss when we deal with a collector lens of given diameter at different distances from the light source.

The first task in the adjustment of the optical train of the projector is, therefore, to ascertain how near an electric arc may be located to the collector lens without causing the lens to break under the influence of rapid expansion and contraction caused by excessive heat. It is this factor which forms the basis of the lens charts, and the arc is automatically placed the minimum distance it is possible to establish the crater of an electric arc of a given amperage from a lens when lens charts are used. It is partly because of the fact that when Moving Picture World lens charts are applied this minimum distance is automatically established that we earnestly recommend all projectionists whose amperage is within the limits of the charts to use them. It is hardly a practical thing for the projectionist to determine by experiment exactly what the minimum distance is, and then figure out the lens combination necessary to give the proper size spot at the proper distance.

OPTICS OF THE CONDENSER.—The condenser may be composed of either two or three lenses, but the universal practice both in the United States of America and Canada is to use only two, though to some extent in England the three-lens combination is used, and in Germany we understand that it is used almost exclusively. In the two-lens combination the lens next the light source is known as the "collector" lens, and the front lens is known as the "converging" lens. Where there is a three-lens condenser the lens located between the collector and converging lenses is known as the "centre" lens. There are great possibilities for light loss inherent in the condenser itself.

DISCOLORED LENSES.—When light passes through perfectly clear, colorless glass of good quality, only a very small percentage of its energy is absorbed. In this we refer only to the actual passage of light through the glass—not the loss incident to reflection as the light enters and leaves the lens. Competent authorities place this absorption loss at about 1 per cent. per each inch of glass, for high grade glass. Other competent authorities place it at about .5 of 1 per cent. per centimeter, which is a little higher than 1 per cent. per inch.

When a lens is discolored experiments have proven that the actual absorption loss is not greatly increased. The following figures are from measurements of discolored condenser lenses and give some idea of what it amounts to:

Kind of Discoloration	Focal Length Plano-Convex Lens.	Percentage of light passed by discolored lens as compared to light strength without any lens at all.
Slight green	7 7/16 inch	88.8 per cent.
Pressed lens, yellow	7 1/16 "	89.2 " "
Pressed lens, yellow	7 1/16 "	88.8 " "
Dark green	6 11/16 "	87.2 " "

Many other lenses were measured, but the results were all within a range of 89.2 high and 87.2 low. When it is considered that both reflection and ordinary absorption losses are recorded together with the color loss, it is seen that the color loss must be slight.

It does not, however, at all follow that color in condenser lenses is not harmful. As a matter of fact it is harmful, because it changes and injures the color value of the light. True, the color may not actually absorb very much of the total light, but it does alter and lower its value for projection purposes. For instance: The light from a condenser having a greenish cast is "muddy." It is not clear and brilliant, hence its value for projection purposes is lowered.

It seems, however, that the pink color sometimes found in condenser lenses which have been used for a time may possibly not be detrimental, but in fact beneficial. Now that we know color in the lens does not, as formerly presumed, necessarily mean excessive loss of light, it might be well to experiment with color to some extent, but if this is done the colors must be confined strictly to those tending to mellow the light, without seriously affecting its brilliancy. A slight pink tinge might be beneficial. At least this discovery opens up a field for investigation, though the fact that tinted film must be projected cannot be overlooked.

AVOID COLOR.—But in any event, except for experimental purposes, until this matter be finally settled, the projectionist should avoid all color. In purchasing lenses, any lens which shows the slightest trace of color, when looked through EDGEWISE, should be promptly rejected.

In examining lenses for discoloration, however, be very certain that any apparent color is actually in the lens itself, and not due to surroundings.

THROW THEM AWAY.—The projectionist should always look through his condenser lenses edgewise when cleaning them, and should any discoloration appear he should promptly discard the lens, explaining to the manager that the lens may in a very short time use up the price of a new lens in light brilliancy. This should invariably apply to green, and should be the rule for all colors, until such time as it may become an established fact that certain colors are desirable—if it ever is.

PITTED LENSES.—When using certain types of carbon there is a decided tendency to pitting of the collector lens. The question is often asked, does this pitting cause light loss? The answer is, to a certain extent, yes, but this loss is not as large as might be supposed. The pit consists of a spot from which the polish of the lens has been burned by impact with incandescent bits of carbon or metal. The light rays striking the lens at this spot are diffused, and a greater percentage of the light is reflected from such a spot than would be reflected if the polish were perfect. The diffused light, of course, passes through the lens and reaches the spot. Just exactly what loss there may be, other than that due to reflection at the point of incidence, we are unable to say. We believe, however, that practically all the light passed by the pitted spot will reach the spot. It seems to us, however, that a pitted condenser must necessarily place a considerable additional strain on the optical properties of the rest of the system, which may result in loss of definition of the picture. Of this we are not entirely certain, but believe it to be true because of the fact that the pitted point will diffuse instead of refracting the rays which strike it.

In any event, bearing in mind the fact that condenser lenses are a comparatively cheap commodity, and that any injury to the screen result will inevitably result in the sale of less seats, we would suggest that it is poor policy to use a badly pitted condenser lens. Better throw it away and install a lens that you know is all right.

THICKNESS OF LENSES.—Projectionists will have observed that some condenser lenses have a very thick edge, and some a rather thin edge. The condenser lens should by all means be standardized in these dimensions. It is necessary that a condenser lens edge have at least 1/16th of an inch thickness, because if it were brought right down to a sharp edge the tendency to breakage would be greatly increased. 1/16th of an inch is, however, ample, insofar as prevention of breakage be concerned, and since additional thickness of a glass tends in any event to absorb light energy to some extent, especially if the glass be of poor quality, it therefore follows that condenser lenses should have a standard edge thickness of 1/16th of an inch, thus minimizing the thickness of the lens.

In Fig. 37 we see at A a lens having unnecessary edge thickness, and at B a lens having the correct thickness of edge. Condenser lenses should have standard 4½ inch diameter—not pretty nearly but exactly. Another point is that the more nearly lens edge thickness and diameter be exactly standardized the more nearly will projector manufacturers be able to make condenser mounts which will properly receive and support the lens.

CONDENSER LENS SURFACE.—It is highly essential to even screen illumination and efficiency of service that condenser lenses be ground to a perfectly true surface and well polished.

In Fig. 38 we see a condenser over which is placed a metal plate in which are drilled two small holes near the edge of the lens. The resultant rays pass through the aperture, as will be seen, and are by the condenser directed straight through to spots on the screen.

In Fig. 39 we see the same thing exactly, except that the projection lens has been placed in position. These are actual photographs taken of light rays, exactly as shown. A study of them will, we believe, convince even the most skeptical that the condenser actually directs or projects the ray forward in a straight line toward the spot, aperture and projection lens. Now if the converging lens has not a perfectly true surface it naturally follows that instead of the rays being all directed forward

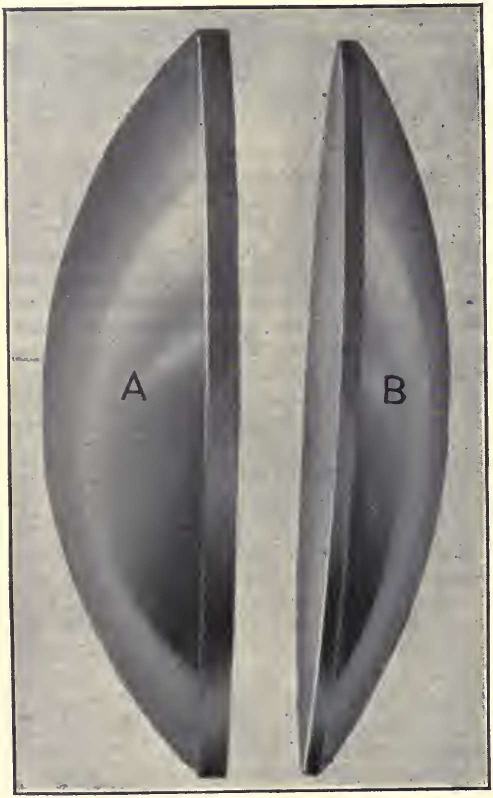


Figure 37.

symmetrically to their proper place, the refraction will be uneven, the resultant illumination of the film will also be uneven, and since the projection lens receives the image of the film exactly as it is illuminated by the condenser, it follows that the screen itself will be unevenly illuminated.

We learn from this the importance of having a condenser with a ground surface of perfectly true curvature.

The condenser lens which has poor polish will be a source of continual loss, because the poorly polished surface will

Figure 38.

reflect a greater percentage of the light than will one with high polish. Optic Projection, page 602, paragraph 841, says:

The polished surface of a lens reflects some light, about 4 per cent. or 5 per cent. at each surface between glass and air; 8 per cent. to 10 per cent. for each lens or plate of glass. If the surfaces of the glass be not perfectly clean or perfectly polished the light losses may amount to much more, sometimes 15 per cent. at each surface.

We thus see the great importance of having not only perfectly clean lenses but lenses with highly polished surfaces.

TYPES OF CONDENSER.—In the United States and Canada only two types of condensers are in use, viz.: The plano-convex and the meniscus bi-convex two-lens combination, both having a standard diameter of 4½ inches, and a free opening of about 4¼ inches when unobstructed by a slide carrier.

The plano-convex combination consists of two plano-convex lenses, such as are shown in Fig. 37, set with their convex surfaces toward each other. The only effect of placing these lenses with their flat sides together would be a greater loss in reflection from the surface of the collector lens, and decidedly more spherical aberration. The meniscus bi-convex consists of a meniscus collector lens, which same is a lens having a convex surface on one side—the side toward the screen—with a slightly concave surface on the other, and a bi-convex lens, which is a lens having two convex surfaces.

Figure 39.

The ordinary custom is to use the plano-convex combination, except under conditions where it is desirable to have the maximum possible distance between the condenser and film with the least possible distance of the arc from the lens, in which case the meniscus bi-convex combination is substituted. The advantage of the meniscus bi-convex combination is that a meniscus lens has a shorter working distance than either the plano-convex or the bi-convex of equal focal length, hence it may be used to advantage in reducing the working distance (distance from lens to light source) without enlarging the spot, or to reduce the size of the spot without increasing the working distance.

Some projectionists claim other advantages for the meniscus bi-convex, but up to this time these advantages have not been demonstrated to the satisfaction of the author of this work, though it is possible there is some reduction of chromatic and spherical aberration by reason of the fact that the negative curvature in the meniscus to some extent neutralizes the positive curve. The negative curve is so slight, however, that we believe its effect will be more than counterbalanced by the additional aberration set up by the bi-convex lens

SMALL DIAMETER CONDENSERS.— In some countries it is the general custom to use a three-combination condenser of considerably smaller diameter than our standard. With this practice we are not well acquainted, but it undoubtedly possesses some points of excellence, particularly under certain conditions. In cases where heavy amperage is used, with the consequent large crater and short distance between the condenser and film, and the resultant wide divergence of the beam beyond the aperture, there will be no advantage in the 4½ inch condenser if the divergence of the beam be such that the ray cannot be picked up in its entirety by the projection lens. In cases of this kind there certainly would be advantage in a smaller diameter condenser, if for no other reason than that it would give a thinner lens, with consequent slightly less light absorption, and the possible shorter working distance between the crater and the collector lens. We believe projector manufacturers would do well to examine into the merits of the small diameter three-lens condenser combination more closely than has, so far as we have knowledge, been done in this country up to this date.

One other serious disadvantage of the larger diameter condenser is that its outer zones produce considerable chromatic aberration, and this impure light is carried down into the centre of the beam at the spot by spherical aberration, which tends to lessen the brilliancy of the whole spot.

SPACING OF CONDENSER LENSES.—No matter what your condenser combination may be, the lenses should always be spaced so that the nearest surfaces are within not more

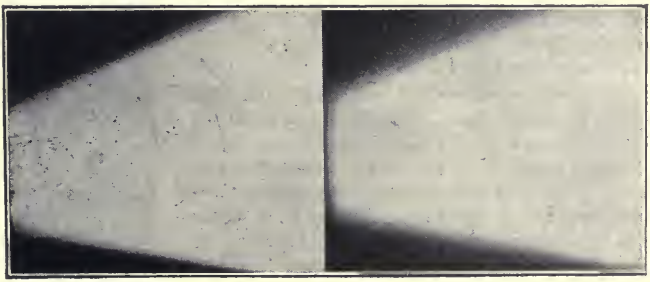


Figure 40.

than 1/16th of an inch of each other. Optically the best possible position would be with the surfaces actually in contact, but this would communicate heat from the collector lens to the converging lens by mechanical means, which would be highly objectionable. The lenses should be just sufficiently separated to avoid this.

Lens tables are calculated on the equivalent focus of condenser lenses set with their nearest point of contact separated not to exceed 1/16th of an inch, and spacing the lenses further apart has the effect of altering the equivalent focus of the combination, besides setting up additional and unnecessary loss as follows:

LIGHT LOSS BETWEEN THE CONDENSERS.—The collector lens, the one next the light source, does not send forward a parallel beam when the arc is in correct position for projection.

In Fig. 40, we see the rays sent forward by a 6.5 inch focal length collector lens, when the arc is in projection position.

Now stop and consider for a moment. Examining Fig. 40, it will readily be seen that loss of light will occur between the lenses of the condenser, and the farther away the converging lens is from the collector lens—the greater the separation of the two lenses—the greater the loss will be because of the fact that the outer margin of the beam sent forward by the collector lens falls outside the converging lens.

The projectionist has only to observe the ring of light surrounding the converging lens of his own projector to understand the truth of this.

CONDENSER MOUNTS.—Most of the late types of professional projectors have very good condenser mounts. A condenser mount should have the following points of excellence: (a) accessibility, in a way that will allow the projectionist to readily get at the lenses and to remove a hot lens with a minimum effort and in a minimum space of time; (b) the lens should be in firm contact with the metal of the holder around its entire edge, and the lens holder should be so calculated that it will act as a heat equalizer, causing the thin edge of the lens to heat up and cool down as nearly as possible at the same speed as does the thick centre of the lens; (c) the lens holders should be so made that the distance between them may be altered quickly and conveniently from the outside of the casing, in order to properly adjust the distance between lenses of varying thickness, or to adjust them for other reasons; (d) the condenser holder should be strongly and substantially made, and when in projection position should be locked firmly in place; (e) modern methods favor the placing of the condenser inside the lamp house, which is, in our opinion, the better practice, since it subjects the whole condenser to the even, though high, temperature of the lamp house interior.

CONDENSER BREAKAGE.—Often this is a difficult thing to deal with. Cases of excessive breakage have come under the observation of the author for which there was, apparently, no reason. As a general proposition, however, always provided the condenser lenses be properly mounted (see condenser mounts, page 365) excessive breakage will be found to be due to one of three things, viz.: (a) an improperly selected or improperly adjusted optical system which places the arc too near the collector lens; (b) excessive heat in the lamp house due to improper ventilation thereof (see lamp house ventilation, page 362); (c) excessive flaming of the carbons.

WHAT THE CONDENSER DOES.—The condensing lens acts, in a way, the same as does a photographic lens, forming an image of the floor of the carbon crater, or the Mazda filament, though the whole of the first named is not in focus at one plane, because it sets at an angle to the plane of the lens. The floor of the carbon crater is not, as has been demonstrated by experiment, of even luminosity. This is probably due to variation in the carbon itself, and to the further fact that the core in the center of the carbon offers a different degree of luminosity to the area of the crater surrounding it. If, therefore, the condenser project forward to the film plane a sharply focused photograph of the floor of the crater it follows that the film will be unevenly illuminated, and since the film is one of the conjugate foci points of the objective lens, also follows that the screen itself will be unevenly illuminated.

It therefore is important that the actual image of the crater be more or less "broken up," which is in good measure accomplished by reason of the fact that the floor of the crater does not set parallel with the plane of the lens, hence is not and cannot be focused in its entirety at the film plane, and to the further fact that the condenser contains considerable spherical aberration, which has the effect of helping to break up the image, and thus produce an evenness of illumination at the film plane.

LOCATION OF CRATER IMAGE.—In the stereopticon the image of the crater is focused within the projection lens itself. Theoretically this would be the proper place to focus the crater in motion picture projection, but in practice it is found that where the light source is a carbon crater this is not practical. It is difficult, if not impossible, to get evenness of screen illumination with the main point of focus of the crater too near the aperture. The practice which generally gives good results is to focus the center of the crater slightly

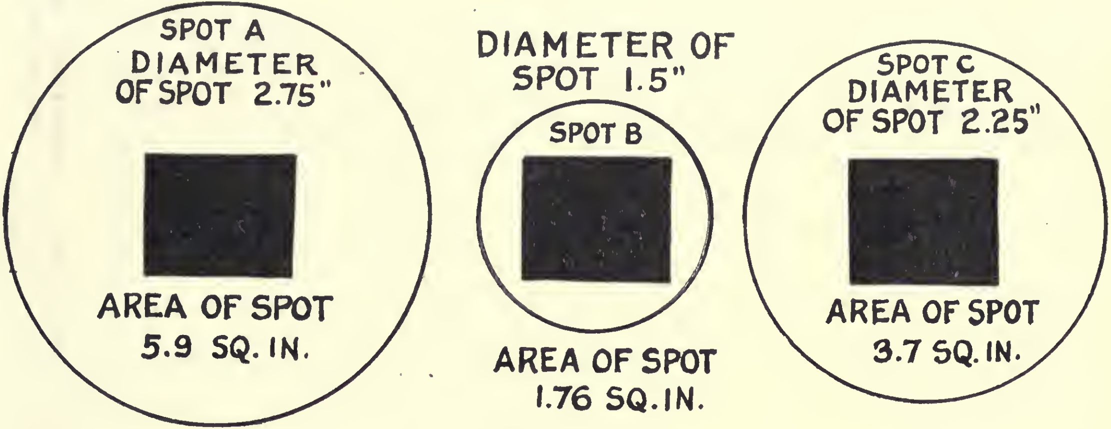


Figure 41.

Percentage of total light passing through apertures Spot A, 13%.
Percentage of total light passing through apertures Spot B, 43%.
Percentage of total light passing through apertures Spot C, 19%.
Percentage of total light loss using Spot A..................87%.
Percentage of total light loss using Spot B..................57%.
Percentage of total light loss using Spot C..................81%.

on one side or the other of the film plane, but if an attempt is made to focus the crater image too far on the projection lens side of the film plane the ghost zone of the condenser beam (see page 177) will be encountered.

This point has caused a great deal of discussion and dissension among those striving to solve the problem of the optics of the projector. Theoretical opticians have insisted on basing their calculations for motion picture optics on a crater focused either within the projection lens or else far on the screen side of the film, and this has been one of their stumbling blocks, since it just simply refuses to work out in practice.

SHAPE OF SPOT.—The projectionist will do well to study the shape of his spot, since in it he finds a direct indication of the condition of his crater. He should remember that the spot is an out-of-focus image of the floor of the crater, and that the more nearly round the spot is the more nearly his crater condition will be found to be perfect, insofar as has to do with light projection. A perfectly round sharply defined spot is a very good indication that the crater is good, and that its position with regard to its angle to the lens is good. See high intensity arc, page 773.

SIZE OF SPOT.—When we consider the size of the spot at the aperture of the projector we find it a subject full of complications. About the smallest spot that can be carried with an assurance of maintaining a clear screen is 1½ inches in diameter. The modern projectionist, however, as a general proposition prefers the 1.75 inch-diameter spot, since with the smaller one there is always the chance for the appearance of discoloration of the light on the screen, a thing which must at any cost be avoided.

Fig. 41 is the diagrammatic representation of the possibilities for loss of light through unnecessary enlargement of the spot. With a spot 1.5 inches in diameter, only 43 per cent. of its area covers the aperture, the rest being intercepted by the cooling plate. We thus see that with a spot of minimum practical diameter, 57 per cent. of its area is intercepted by the cooling plate. If we increase the size of the spot to 2.75 inches diameter, then the aperture will only cover 13 per cent. of the area of the spot, 87 per cent. of which will be intercepted by the cooling plate.

The obvious lesson of this is that an unnecessarily large spot is an enormous waster of light, hence of electric energy.

In this connection let us consider that

The main point in deciding upon the focal length of the condenser, is to secure a focal length which will establish the crater produced by the amperage to be used at the minimum practical distance from the collector lens, at the same time giving the smallest practical diameter of spot and a maximum distance from the center of the condenser to the aperture. (See page 162.)

The latter, however, is only of importance in cases where, due to the large diameter crater produced by high amperage, it is difficult to secure sufficient distance between the center of the condenser and the aperture to confine the divergence of the beam beyond the aperture within limits which will enable the objective to pick up the entire beam, and at the same time keep the spot at the minimum practical working diameter.

In considering the relation of the focal length of the condenser to the size of the spot, to the distance from the center of the condenser to the spot, to the size of the crater, and to the distance of the crater from the center of the condenser, let is be clearly understood that while the office of the condenser is to intercept as much as possible of the light emerging from the crater, and to concentrate it on the aperture, it after all, in so doing acts precisely the same as would a photographic lens. With a condenser of given focal length, and a crater of given diameter, the diameter of the spot will be as many times the diameter of the crater as the distance from the apex of the curved surface of the collector lens to the floor of the crater is contained times into the distance from the apex of the curved surface of the converging (front) lens to the aperture, when the curved surfaces of the lenses are not to exceed 1/16th of an inch apart. For instance: If the distance from the apex of the curved surface of the collector lens to the aperture is 16 inches, the distance from the apex of the curved surface of the collector lens from the floor of the crater 4 inches, and the crater is .5 of an inch in horizontal diameter, then the resultant spot will be $16 \div 4 = 4$, and $4 \times \frac{1}{2}$ inch $= 2$ inches in diameter. This applies equally for both plano-convex and meniscus bi-convex lenses, except that when figuring the meniscus bi-convex, instead of figuring from the curved surface to the floor of the crater we figure the distance from a point $\frac{1}{8}$ of an inch in front of the convex face of the meniscus lens, and the other distance from the center of the bi-convex to the aperture.

With the foregoing in mind it readily will be seen that the necessary enlargement of the crater image at the spot will depend on the number of amperes we are using, since the diameter of the crater increases in proportion to the number of amperes used. (See Page 393.) The distance from crater to apex of curved surface of collector lens, and from the apex of curved surface of converging lens to film, are known respectively as "distance X" and "distance Y." The points from which they start are shown in Fig. 42.

The average projectionist who reduces his spot diameter by pulling his lamp back a greater distance from the face of the collector lens is more than likely to discredit the foregoing, because, while he has decreased his spot diameter, he has either not increased the screen illumination at all, or to no appreciable extent.

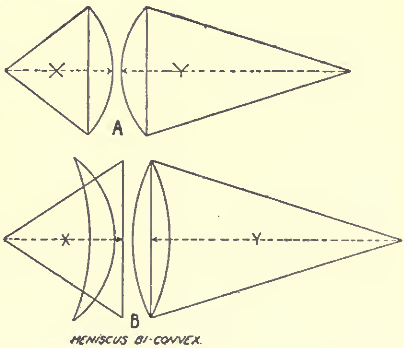


Figure 42.

The fact is, he has not acted intelligently. He should have installed a shorter focal length condenser in order to maintain his arc-to-lens distance at minimum, at the same time setting up a condition which would cause a heavier convergence of the beam on the other side of the lens.

Of course we realize that intelligent work in this direction is hampered by difficulty in securing lenses of necessary focal lengths, but much may be accomplished, nevertheless, and the whole matter forms an interesting and profitable field for experiment and study on the part of projectionists and engineers.

The problem is to keep distance X the minimum possible without setting up excessive lens breakage, at the same time maintaining a maximum distance and standard diameter spot.

In this connection remember that:

The spot diameter will always be as many times the diameter of the crater as distance X is contained into distance Y.

SLIDE CARRIER WASTE.—The loss of light caused by fixing a slide carrier permanently in place in front of the condenser is illustrated in Fig. 42A.

Lack of understanding and appreciation of such things causes what is literally a tremendous amount of waste of light, which means electric energy, when we come to consider motion picture theatres as a whole. Each theatre may waste but comparatively little, but there are many thousands of theatres.

CRATER IMAGE UPSIDE DOWN.—Due to the fact that the condenser reverses the image of the crater in projecting it, the image of the crater is upside down at the spot. In some cases where the bottom of the crater is in fairly good focus at the cooling plate it is possible to discern the image of the lower carbon tip at the top of the cooling plate. It may often be clearly seen when feeding the carbons while the arc is burning.

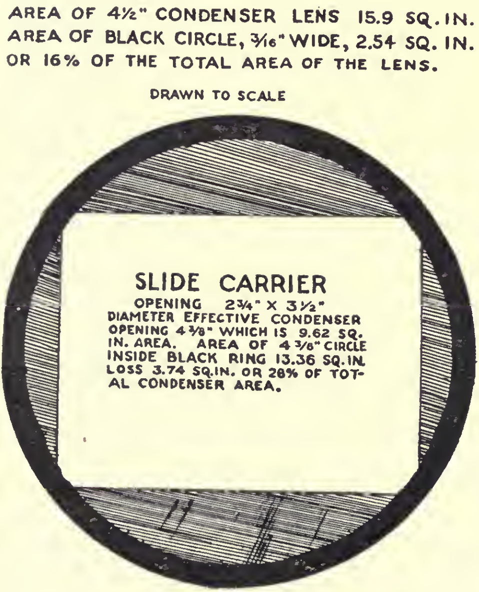


Figure 42A.

GHOST ZONE. — The condenser beam carries a well defined ghost zone. This is due to chromatic aberration, which is always present in uncorrected lenses such as those used for condensing.

In Fig. 43 a crater is constructed by cutting an aperture in a piece of cardboard and placing over it a bit of ground glass, behind which we establish a 100 C. P. incandescent lamp. The crater and the screen are placed at conjugate foci points of the plano-convex condenser, as shown. The screen corresponds to the aperture of a projector. We cover the front surface of the collector lens with a piece of cardboard in which is a pin hole located as shown.

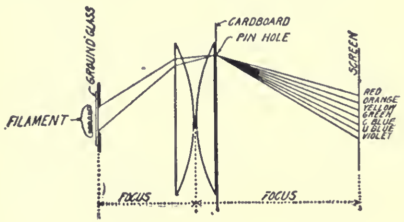


Figure 43.

The results as observed upon the screen are: The crater is focused in full definition, but is colored with the shades of the spectrum in the manner shown. It has been demonstrated by the Kinemacolor process that all the colors of the spectrum may be reduced to approximately two shades, viz.: A reddish-orange and a bluish-green, which, for the sake of clearness, we will call orange-green.

In Fig. 44 the same conditions are shown as those described in connection with Fig. 43, except that the colors of the spectrum have been reduced to the two primary shades, viz.: Orange and green. You will note that under this condition at the screen (or aperture) the colored rays have combined and formed white light.

Now if the process shown in Fig. 44 be continued, and a very large number of rays be drawn, using orange and green ink, the result will be as illustrated in Fig. 45, which is merely Fig. 44 elongated to more nearly approach actual working conditions.

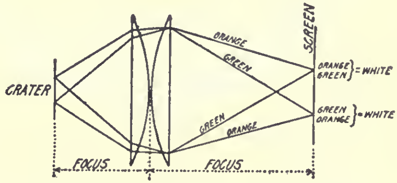


Figure 44.

In Fig. 45 it is observed that the beam is enclosed by an orange envelope, which is thickest toward the central part of the beam and comes to a point, or is not present at the aperture and the condenser. The beam has a core in its center, which same is composed of the violet, the blue and the green shades of the spectrum. The white part of the beam is caused by the mixture of the two other primary shades, but the mixture is not perfect at all positions. At AA Fig. 45 the white light is most pure, but as it approaches position BB the colors at the faulty end of the spectrum begin to predominate, so that at section BB the white zone has changed to a dirty purple. Considering this condition we may readily understand why a ghost appears when the condenser is brought far enough toward the aperture.

When the aperture is properly located, all the colors of the beam finally combine at that point to form pure white light, and all light beyond the aperture is white.

It must, however, be remembered that the results shown in Fig. 45 can only be approximately true, since all the colors of the spectrum, which are infinite in number, have, for the purpose of the experiment, been reduced to two shades.

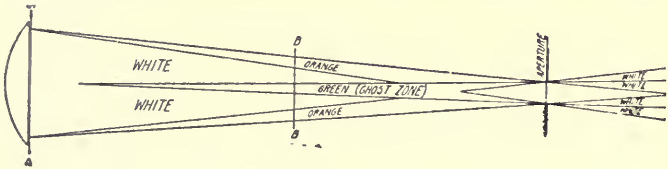


Figure 45.

Even if only seven of the primary colors have been used in the drawing, the straight lines in Fig. 45 would show as curves, and more closely resemble the true shape of the actual beam.

The projectionist is not able to see these various zones with the naked eye. The fact remains, however, that while invisible to the eye they are there, and it is their presence which causes the blue spot to appear in the center of the screen when the aperture is brought too near the condenser, or the crater is advanced too close to the collector lens, which latter has the effect of advancing the ghost zone nearer to the aperture.

PURE LIGHT.—In this connection one of the important functions of having the crater as nearly as possible in focus at the aperture is to purify the light and avoid color effects.

ADJUSTING THE PROJECTOR OPTICAL TRAIN.—Before attempting the adjustment of the optical train it will be well to carefully study and consider all those various things which have already been set forth under the general heading "Lenses," beginning at page 125. We will provide you with the necessary charts and diagrams, by the application of which you will be able to so adjust your projector optical system that maximum results will be had, both in brilliancy and evenness of screen illumination, and, what is almost equally important, they will be had at maximum efficiency.

It must be remembered, however, that where local conditions vary so widely, even the most carefully calculated and prepared formula is likely to in some measure fail of its highest purpose unless it be applied with intelligence and understanding. It is for this reason we urge projectionists to study and come to an understanding of the underlying principles which govern in the selection and adjustment of the projector optical system.

It is a deplorable fact that the lack of such understanding on the part of projectionists, coupled with the failure of condenser lens manufacturers to provide proper lenses and the failure of theatre managers and exhibitors to purchase optical equipment of the right design and quality, has, ever since the very inception of motion picture projection, not only caused a literally huge waste in light, which means a waste in electric energy, but has also made it impossible to exactly duplicate the illumination of all points of the film photograph upon the screen, without which it is impossible to secure the same apparent depth in the picture which the natural scene presented to the "eye" of the high grade camera lens, and which was by that lens impressed faithfully upon the film.

It has often been remarked that the same photoplay has an apparently increased stereoscopic effect, or perhaps we might better say a greater "depth" in one theatre than in another, and this has been placed to the credit of the screen, whereas the real credit was not due to the screen at all, but to the correct selection of the various elements of the optical system and their correct adjustment with relation to each other, so that the film image was evenly illuminated and the evenness of illumination was faithfully transmitted to the screen.

One of the big outstanding facts in projection is that evenness of illumination is absolutely essential to perfect results on the screen, and evenness of illumination at the screen is impossible unless we first secure evenness of illumination of the film photograph at the aperture, and then project the

even illumination of the picture at the aperture to the screen without change.

It is a comparatively simple problem to secure at least a high degree of evenness of illumination at the aperture, but a study of the subject will convince even the most skeptical that unless the projection lens receive an equal amount of light from every point of the area of the aperture there cannot possibly be evenness of illumination at the screen.

Figure 46.

If the student will carefully examine Fig. 46 and apply its meaning he will, for one thing, immediately know that a projection lens which has not sufficient diameter to receive the entire beam from the aperture, cannot possibly distribute evenness of illumination of the film photograph to the screen.

Fig. 46 is a photograph, in which X is a standard projector aperture, mounted on an optical bench, over which has been placed a plate of metal in which two minute holes were drilled. This aperture is illuminated by a standard spot from a regular projector plano-convex combination condenser, placed with its center 18 inches from the aperture. 1 is the rear combination of the projection lens, and 2 the front combination, space Y having been sawed out of the lens barrel so that we were able to look right into the lens and watch the action of the rays. Smoke was blown into the light beam, thus making it visible and enabling us to photograph the results. Absolutely no change has been made in the photograph, except that we have drawn in the black dividing lines between the two light cones which, while quite visible in the photograph itself, would not show in the printed reduction.

Considering Fig. 46 you will see that a cone of rays goes forward, diverging fan-shaped, toward the projection lens. That this is true. you ought to know because, since every pin point of the film photograph must be refocused on the screen in its appropriate place, it follows that the illumination it receives must go forward to the projection lens as a separate unit, and by the projection lens must be sent forward to its appropriate spot on the screen.

Consequently we must treat every pin point of the film photograph as an entirely separate proposition from every other pin point when we consider the item of illumination, and the projection of that illumination to the screen.

If every portion of the film photograph is evenly and equally illuminated it follows that the light from each pin point of the film goes forward toward the projection lens as a cone-shaped bundle of rays, the base of which is at the

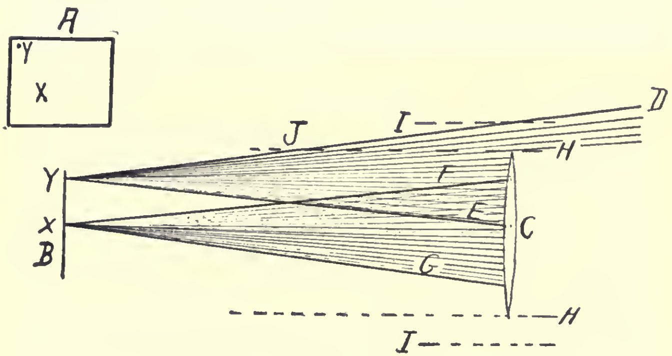


Figure 47.

projection lens. Since the amount of divergence of the rays is in exact proportion to the diameter of the condenser and its distance from the aperture, the cone starting at the center of the film picture is always likely to enter the projection lens in its entirety, which means that the full value of the illumination passing through that point will be projected forward to its appointed place on the screen, giving the center of the picture on the screen what we may call 100 per cent. illumination, appearing to the audience practically the same as it appeared to the eye of the camera.

On the other hand, again considering Fig. 46, suppose one of these cones to have its point at the extreme corner of the projector aperture. This cone will also diverge equally with the one in the center of the picture, and if the projection lens has insufficient diameter to receive its entire base, it is apparent that a portion of this bundle of rays will fall outside the projection lens, hence will not be projected to the screen. This, of course, means that that particular point of the film photograph will be deficient in illumination, and therefore will not have the apparent depth presented by the center of the picture.

That this unevenness of illumination may not be in any degree apparent to the eye when the blank screen is viewed proves nothing, because the eye is unable to detect unevenness of illumination under those conditions unless it be very great indeed, or unless the weak points be also discolored. But it can and does detect the difference in apparent depth of the picture, though it does not recognize it as such. In fact, it does not recognize it at all, and could not possibly recognize it except in case two projections of the picture be placed side by side, one evenly illuminated and the other not evenly illuminated. **The eye would then see that the evenly illuminated picture was much more pleasing than the one which was unevenly illuminated.**

In Fig. 47 we have diagrammatic representation of what we have been talking about with relation to Fig. 46. A is a standard aperture in which dots X and Y represent respectively two pin points in the film photograph, one in the center and one in the upper left hand corner. B is a line representing a side view of the same aperture. C is the back factor of a 1½-inch-diameter projection lens, at 4-inch working distance. Cones D, E, F and G are laid out exactly as they would be with a standard diameter condenser converging lens located 18 inches from aperture B. Dotted line H—H represents the diameter of projection lens C. In other words, lines H—H represent the diameter of lens C at any point within their length, and we may readily see that in order to take in the entire cone D—E, the lens would necessarily have to be moved towards the aperture to point J. Dotted lines I—I represent the diameter projection lens C would have to have in order to accommodate cone D—E in its entirety.

It seems hardly necessary to point out the very obvious fact that under this condition the center of the screen image must and will, in the very nature of things, be better illuminated than will the outer margins. In other words, under such a condition it is utterly impossible to have an evenly illuminated picture on the screen.

BEAM DIVERGES BEYOND APERTURE.—That the beam does diverge beyond the aperture (between aperture and projection lens) is amply proven in Fig. 48, which is the photograph of a standard projector aperture illuminated by a condenser, exactly as in practical projection. By laying a straight edge along the upper line of the diverging ray it will be found to just touch the lower edge of the condenser, and if the straight edge be laid on the lower edge of the light ray it will just touch the upper edge of the condenser, proving that the divergence of the ray is in exact proportion

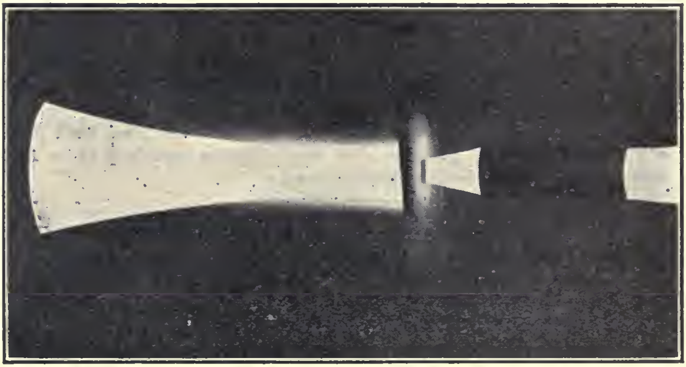


Figure 48.

to the diameter of the condenser and its distance from the aperture, the size of the projector aperture being always standard.

In Fig. 49 we have the photographic representation of what happens when the projector lens has insufficient diameter to receive the entire light beam. This not only results in serious loss of light, but, as has already been explained, causes unevenness of illumination on the screen and detracts seriously from the depth of the picture.

PROJECTION LENS DIAMETER AND CONDENSER DISTANCE.—Fig. 50 is the diagrammatic representation of the effect of distance of condenser from aperture on projection lens diameter. In this drawing we have a condenser with the face of the converging lens located 16 inches from the aperture. The broken lines indicate the divergence

Figure 49.

of the beam at the plane of the projection lens, which is presumed to be 5 inches from the aperture—a 5-inch working distance. We have another condenser lens, of equal diameter, located 21 inches from the aperture, the divergence of the beam from which is indicated by the solid lines. We thus see that the removal of the condenser to a greater distance from the aperture has the effect of narrowing the divergence of the beam beyond the aperture, thus permitting the use of a projection lens of smaller diameter. But let it be clearly understood that as we increase the distance from condenser to aperture it will be necessary to install longer focal length condenser lenses in order to maintain the size of the spot (assuming, of course, that the crater was in the first instance, the minimum distance from the face of the collector lens for the amperage being used), and the installation of a longer focal length condenser means that the crater will be farther away from the plane of the collector lens. This automatically sets up light loss (see Fig 36H), in that it reduces the amount of light flux falling upon the surface of the collector lens, but if the projection lens was of too small diameter to pick up the ray, the increased amount of light it will receive by reason of the narrowing of the divergence of the ray will more than compensate for the loss at the condenser.

CAUTION.—This is one of the things which must be applied with understanding, and the more thoroughly the projectionist understands all the various propositions involved the better result he will be able to attain, both in screen illumination and efficiency.

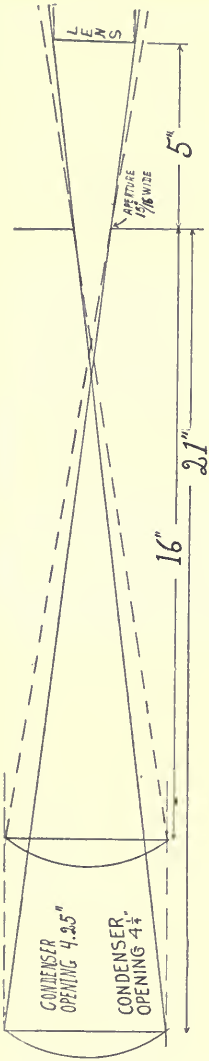


Figure 50.

LIGHT LOSS THROUGH DIVERGENCE.—The following charts are from actual photometer readings of the ray at points A, B and C, Fig. 51. **The black circle in each of the charts represents a projection lens with 2 inch free diameter.**

Fig. 52 is a measurement of the light beam 3 inches from the aperture, on the projection lens side of course (position A, Fig. 51), with the condenser located with the face of the converging lens 10 inches from the aperture. Fig. 52 is a measurement made under the same condition, but taken at position B, Fig. 51, and Fig. 53 is the measurement at a distance of 7 inches from the aperture, position C, Fig. 51. The black circle shows the area of the beam a 2-inch free opening projection lens would cover.

Figs. 54, 55 and 56 are measurements made at position A, B and C, Fig. 51, but with the face of the converging lens of the condenser 18 inches instead of 10 inches from the aperture.

Examining these charts we find several surprises. Let us take Fig. 53 for example, first, however, being sure you understand exactly what is being done. Imagine yourself looking at the front, or projection lens side of the aperture of a projector from which the revolving shutter, front plate and projection lens have been removed. You are then looking toward the condenser and into what we will, for lack of a better term, call the "end" of the light beam from the condenser after it has passed through the aperture. The beam will spread out fan-shaped (diverging), as shown photographically in Fig. 48 and diagrammatically in Fig. 51, the divergence being in proportion to the distance of condenser from the aperture. Pardon the repetition, but it is essential that you grasp this fact and understand it clearly.

Looking thus into the end of the light beam, we occupy

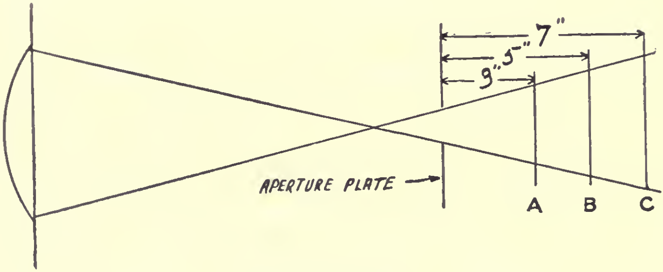


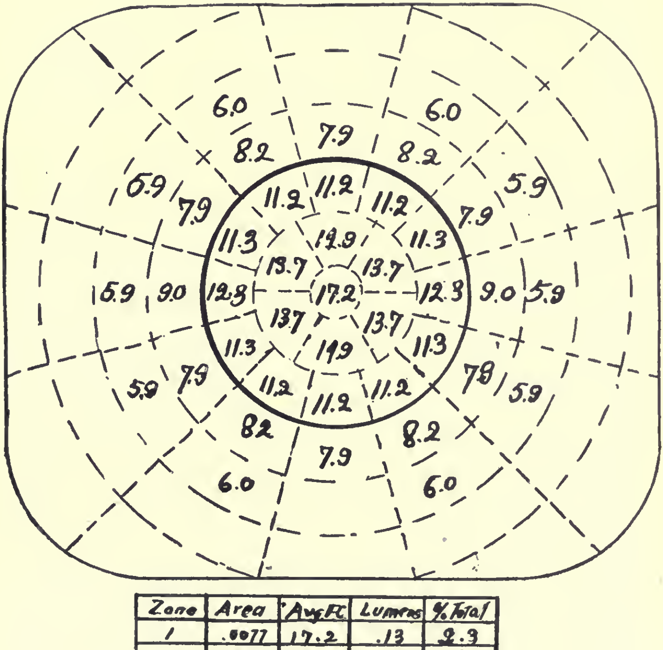
Figure 51.

the position of the photometer which measured the intensity of every portion of the beam in half inch sections of its area. In their outline all the charts show the exact shape and exact size of the beam at the point of measurement, which in Fig. 53 is at 5 inches from the aperture when the face of the converging lens of the condenser is 10 inches from the aperture. Each circle is a "zone" one-half inch wide, and each division thereof represents, in the figures printed on it, a measurement of its light intensity.

This understood let us proceed to analyze chart 53 and its accompanying tabulation. The center zone shows a light intensity of 26-foot candles, but it carries a total of only .2 lumens, because it has only .0077 of a square foot area. **Its candle power is high, but its area is small.** It represents the light the area of a ½-inch circle at the center of the lens would receive. It amounts to only 3.4 per cent. of the total light giving power of the entire beam. Next we examine zone 2, which by the tabulation, we see has only an average of about 22 candle power unit area, but carries a total of 1.4 lumens, because it has .062 of a square foot of area. Its candle power per unit of area is weaker, but its area is so much greater than zone 1 that it is found to carry 24 per cent. of the total candle power of the light beam, or almost 8 times as much as the more brilliant center of the beam. Zone 3 we find to have an average of only 14.2 foot candles, but it nevertheless carries 30 per cent. of the total light of the beam, because it has many times the area of either of the other zones.

IMPORTANT.—Zones 1, 2 and 3 carry all the light which can get through the projection lens under the conditions shown. The rest is wasted, and a glance at the tabulation shows that the waste is 21.5 plus 21, or 42.5 per cent. of the total light.

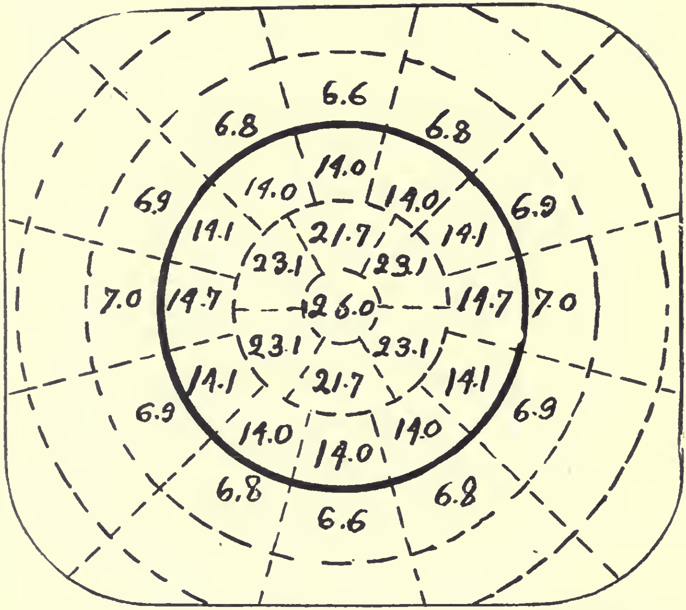
Of course the condition as to condenser location is ab-



Zone	Area	Avg. F.C.	Lumens	% Total
1	.0077	17.2	.13	2.3
2	.062	14.1	.88	15.1
3	.123	11.4	1.40	24.0
4	.183	8.4	1.54	26.4
5	.245	5.9	1.47	25.2
remaining zones			.41	7.0
		Total	5.83	

Figure 52.

Reduced by 1.25 inches, size of actual ray 4⅝x4″.

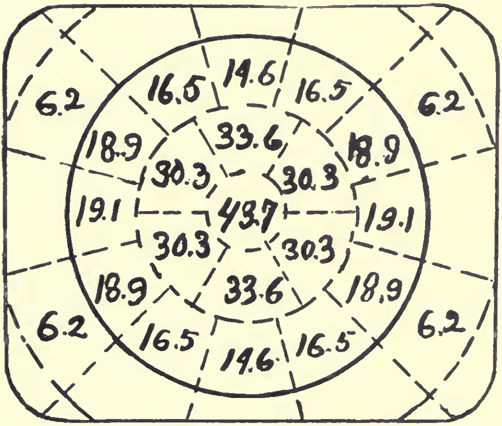


Exact Shape and Size of Ray Five Inches from Aperture, on Projection Lens Side, with Condenser 10 Inches from Aperture.

Zone	Area	Avg. F.C.	Lumens	% Total
1	.0077	26.0	.200	3.4
2	.062	22.0	1.40	24.0
3	.123	14.2	1.75	30.0
4	.183	6.83	1.25	21.5
Remaining zones			1.26	21.0
		Total	5.83	

Figure 53.

normal, since in arc light projection it seldom or never is found so close to the aperture. But Figs. 55, 56 and 57 show a very normal condition—in fact a condition very much better than the ordinary, because it would mean a 19-inch center-



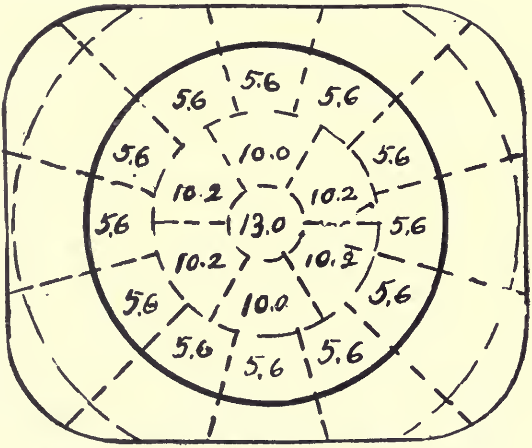
Exact Dimension and Shape of Light Ray Three Inches from Aperture, on Projection Lens Side, When Condenser Is 10 Inches from the Aperture.

Zone	Area sq in	Avg F.C.	Lumens	% Total
1	.0077	43.7	.34	5.8
2	.062	31.4	1.95	33.6
3	.123	17.4	2.14	36.6
4	.113	6.2	1.40	24.0
remaining zones				
		Total	5.83	100.00

Figure 54.

of-condenser-to-aperture condenser position. We have shown you how to read these charts. Their study will be highly enlightening as to the possibilities for waste through wrong condenser position, to say nothing of the loss of depth in the picture caused by unevenness of illumination inevitable under such conditions.

LENS CHART.—An excellent lens chart constructed by John Griffiths was purchased by the Moving Picture World and published in the projection department some time ago.



Seven Inches from Aperture, with Condenser 18 Inches from Aperture.

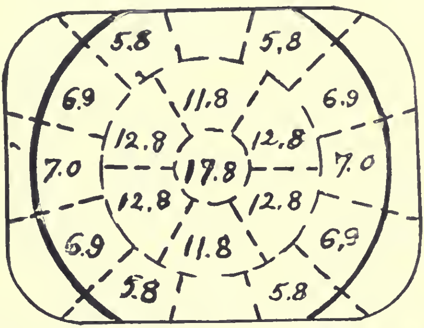
Zone	Area	Avg F.C.	Lumens	% Total
1	.0077	13.0	.10	5.7
2	.062	10.1	.63	36.0
3	.123	5.8	.71	40.6
remaining zones			.31	17.7
		Total	1.75	

Figure 55.

Its range is from 25 amperes to 60 amperes A. C. or D. C. within which limits it has proven iteslf to be efficient and satisfactory. It has a place in the projection rooms of a large percentage of motion picture theatres throughout the English speaking world. The construction of this chart marked a very great advance towards perfection in the adjustment of the projector optical system. We commend it heartily to projectionists whose amperage lies within its range.

It has been found impractical to reproduce this chart herewith in a size sufficiently large to be of practical use. However, large reproductions, measuring 9½ by 15 inches, suitable for placing on walls of projection rooms, can be secured at a nominal price from Moving Picture World.

HOW TO USE THE CHART.—First ascertain, as nearly as possible, what amperage you are using at the arc. If you merely "guess" at it, and don't happen to hit things right don't blame the chart if it does not give perfect results.



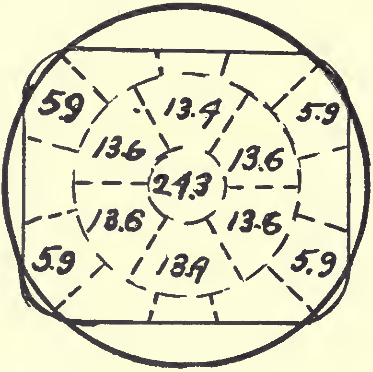
Zone	Area	Avg. F.C.	Lumens	% Total
1	.0077	17.8	.14	8.6
2	.062	12.5	.78	44.6
3	.112	6.9	.77	44.0
remaining zones			.06	3.4
		Total	1.75	

Figure 56.

Be sure that the condenser lenses are at least approximately what they are supposed to be in the matter of focal length and that they are placed in the mount with their curved surfaces separated by not more than 1/16 of an inch.

Let us assume an amperage of 50, D. C., and a projection lens working distance of 5 inches.

The center of the chart is divided by a vertical column marked at the top "Distance to Aperture." The right hand side of the chart is for plano-convex and the left hand side for meniscus bi-convex condensers. Looking on the right hand side we find that for 50 amperes D. C. we should have a 6½ and a 7½ inch converging plano-convex lens, and that the line under 50 D. C. is just a little above the line "17 inches" in distance from the aperture. We shall therefore require a 6½ collector lens and a 7½ converging lens, spaced not to exceed 1/16 of an inch apart, with the center of the condenser just a little less than 17 inches from the aperture. With this combination, since our projection lens is at a 5 inch working distance it must have a 2.2 inch free diameter in order to accommodate the entire beam.



Exact Size and Shape of Ray Three Inches from Aperture When Condenser Is 18 Inches from Aperture.

Zone	Area	Avg. F.C.	Lumens	% Total
1	.0077	24.3	.19	10.8
2	.062	13.5	.86	49.2
3			.70	40.0
		Total	1.75	100.

Figure 57.

If we find our projection lens has less than this free diameter, then there would be some gain in using a meniscus bi-convex set, because, looking under 50 amperes in the meniscus bi-convex side we find that the 6½ meniscus and 8½ bi-convex combination required for 50 amperes gives us a 2-inch greater distance between the center of the condenser and the aperture, so that a 2.1 projection lens working opening will accommodate the ray. Not very much gain, to be sure, but some.

Aside from this gain the meniscus bi-convex does not present much, if any, advantage over the plano-convex, and we believe that the plano-convex and a reduction of condenser diameter would produce better general results. (See page 203.)

UNIVERSAL METHOD FOR ASCERTAINING CONDENSER FOCAL LENGTH AND APERTURE DISTANCE WITH RELATION TO OBJECTIVE DIAMETER.—In Fig. 58 we present a very valuable diagram by the careful, intelligent application of which the projectionist using high amperage will be enabled to get both the correct condenser distance for his objective and the correct focal length condenser to maintain the proper size spot at that distance. This diagram must, however, be used with caution, because there may be a tendency to apply it in cases where the installation of a projection lens of larger diameter would serve better. In other words, it would be bad practice to use this diagram for the purpose of accommodating a projection lens of too small diameter for the work, since if this be done, although there might be some gain as against the former condition, still the ultimate result will not be what it should be, and would be if a projection lens of proper diameter were used. The method of applying the diagram is as follows: First measure both the exact working distance of your projection lens and the exact free diameter of its aperture. Next examine Table No. 8 and in the left hand column find the number corresponding to, or most nearly corresponding to, the free diameter of your projection lens. Now run your finger out along the horizontal row of figures opposite the free diameter of your projection lens until you find the figure most nearly corresponding to its working distance, and at the top of that column will be the distance the center (point midway between the lenses) of the condenser must be from the aperture in order to allow the entire light beam to enter the projection lens.

For example: Suppose the working distance to be 5 inches, and the projection lens aperture 2.5 inches. In the 15th space from the top in the left hand column of Table No. 8 we find 2.5, and in the 11th column to its right we find 5. At the top of column 11 we find 18, which means that under the condition of working distance and lens diameter given, we must have 18 inches from a point midway between the two condenser lenses to the aperture in order to get the entire light beam into the projection lens.

If the working distance had been 5.5 instead of 5, then the right distance would be 18.5 inches, because the next working distance given opposite the 2.25 lens diameter is 5.437, which is practically 5.5 inches, and at the top of this column we find 19 inches. Since 5.25 is half way between 5 and 5.5 we would split the difference between 18 and 19, which would be 18.5 inches. This would, however, have but slight effect, since when we get back as far as 18 inches, an extra half inch further alters the angle but very slightly. Nevertheless, while we are doing the job we might as well do it with precision, therefore under that condition 18.5 would be the distance.

CAUTION.—And now let us caution you that right here judgment and common sense enter. If your projection lens has an aperture of 2.25 inches or less, and it is necessary to retard the condenser to a greater distance than say 18 or 19 inches in order to get the entire beam into it, it would be better practice to get a lens of larger diameter, because retarding the condenser calls for a condenser of longer focal length (E. F.), which operates automatically to place the crater further away from the collector lens, thus weakening the light collecting power of the collector lens, or in other words the total light available to the spot, see Fig. 36-H, page 162.

It is therefore for the projectionist to determine when and where retarding the condenser should cease in favor of increasing the projection lens diameter.

Of course where the projection lens is already of maximum diameter, there is then the choice of retarding the condenser or reducing its free opening because we must secure evenness of illumination at the screen, even though there be actual light loss in the process.

Personally we believe that up to say 18 inches it is better to increase condenser distance than lens diameter, especially if the projector is considerably out of center with the screen, provided the projection lens free aperture be already not less than 2 inches, but if the beam cannot be made to enter a 2-inch aperture lens with a distance of 18 inches, then it is better to seure a projection lens of larger aperture than to set the condenser as far back as may be necessary to get all the beam into the lens. In this we of course assume that projection lenses of desired diameters can be had, which is

DISTANCE CENTER OF CONDENSER OF APERTURE

PROJECTION LENS DIAMETERS

	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 3/8	1"	1.099	1.324	1.472	1.532	1.672	1.785	1.835	2.032	2.122	2.2	2.441	2.54	2.61	2.69
1 7/16	1.086	1.198	1.432	1.590	1.665	1.715	1.942	2.002	2.204	2.309	2.4	2.656	2.76	2.84	2.88
1 1/2	1.173	1.297	1.540	1.708	1.798	1.858	2.099	2.169	2.376	2.496	2.6	2.855	2.98	3.07	3.11
1 9/16	1.259	1.396	1.648	1.826	1.931	2.001	2.256	2.336	2.548	2.683	2.8	3.060	3.20	3.30	3.35
1 5/8	1.346	1.495	1.756	1.944	2.067	2.144	2.413	2.503	2.720	2.870	3.	3.267	3.42	3.53	3.58
1 11/16	1.432	1.594	1.964	2.062	2.197	2.287	2.570	2.670	2.892	3.057	3.2	3.474	3.64	3.76	3.82
1 3/4	1.519	1.693	2.072	2.180	2.330	2.430	2.727	2.837	3.064	3.244	3.4	3.681	3.86	3.99	4.05
1 13/16	1.605	1.792	2.180	2.298	2.463	2.573	2.884	3.004	3.236	3.431	3.6	3.888	4.08	4.22	4.29
1 7/8	1.692	1.891	2.288	2.416	2.596	2.716	3.041	3.171	3.408	3.618	3.8	4.195	4.30	4.45	4.52
1 15/16	1.778	1.990	2.396	2.534	2.729	2.859	3.198	3.338	3.580	3.805	4.	4.402	4.52	4.68	4.76
2"	1.865	2.089	2.504	2.652	2.862	3.002	3.355	3.505	3.732	3.992	4.2	4.609	4.74	4.91	4.99
2 1/16	1.951	2.188	2.612	2.770	2.995	3.145	3.512	3.672	3.924	4.279	4.4	4.816	4.96	5.14	5.23
2 1/8	2.038	2.287	2.720	2.888	3.128	3.288	3.669	3.839	4.096	4.466	4.6	5.023	5.18	5.37	5.46

Table No. 8.

IN FIRST COLUMN

2 3/16	2.124	2.384	2.828	3.006	3.261	3.431	3.826	4.006	4.269	4.655	4.8	5.230	5.40	5.60	5.70
2 1/4	2.211	2.486	2.936	3.124	3.394	3.574	3.983	4.173	4.440	4.840	5	5.437	5.62	5.83	6.93
2 5/16	2.297	2.584	3.044	3.242	3.527	3.717	4.140	4.340	4.612	5.027	5.2	5.644	5.84	6.06	6.17
2 3/8	2.383	2.683	3.152	3.360	3.660	3.860	4.297	4.507	4.784	5.214	5.4	5.851	6.06	6.29	6.40
2 7/16	2.470	2.782	3.260	3.478	3.793	4.003	4.454	4.674	4.956	5.401	5.6	6.058	6.28	6.52	6.64
2 1/2	2.556	2.881	3.368	3.596	3.926	4.146	4.611	4.841	5.128	5.588	5.8	6.263	6.60	6.75	6.87
2 9/16	2.643	2.980	3.476	3.714	4.059	4.289	4.768	5.009	5.300	5.775	6	6.412	6.72	6.98	7.11
2 5/8	2.727	3.534	3.579	3.832	4.192	4.432	4.925	5.176	5.472	5.962	6.2	6.679	6.94	7.21	7.34
2 11/16	2.816	3.178	3.692	3.960	4.325	4.575	5.082	5.343	5.649	6.149	6.4	6.886	7.16	7.44	7.58
2 3/4	2.902	3.277	3.800	4.068	4.458	4.658	5.239	5.510	5.816	6.336	6.6	7.093	7.38	7.67	7.81
2 13/16	2.989	3.376	3.908	4.186	4.591	4.801	5.396	5.677	5.988	6.523	6.8	7.300	7.60	7.90	8.06
2 7/8	3.075	3.475	4.016	4.304	4.724	4.944	5.553	5.844	6.160	6.710	7	7.507	7.82	8.13	8.28
2 15/16	3.162	3.574	4.124	4.422	4.857	5.087	5.710	6.011	6.332	6.897	7.2	7.714	8.04	8.36	8.52
3"	3.248	3.673	4.232	4.540	4.990	5.230	5.867	6.178	6.504	7.084	7.4	7.921	8.26	8.59	8.75

WORKING DISTANCES

Table No. 8.

not always the case, since such lenses are not made in aperture diameters greater than twice their focal length of the lens. Thus: A 4-inch E. F. projection lens cannot be had in greater diameter than 2 inches, and in practice it is doubtful if you could get one of quite that aperture. P. 139 and 148.

UNIVERSAL METHOD OF SELECTING AND ADJUSTING PROJECTOR OPTICAL SYSTEM. IMPORTANT FOREWORD AND EXPLANATION. In what follows the projectionist may not, and probably without this explanation would not understand why he is directed to first make diagram 58 according to the diameter of his present projection lens and then, after applying diagram 58 A, to again apply diagram 58, using the diameter of the new lens as its foundation. He will most likely ask why he could not as well apply diagram 58 A at once, and then apply diagram 58 without bothering with the first application of diagram 58 at all.

The reason is just this: The available projection lenses are strictly limited as to diameters, and it is not at all certain that the projectionist will be able to get the diameter he should have. If the projectionist were to find by application of diagram 58 A and table No. 8 that a lens of the required diameter cannot be had, he is stuck, or will probably think he is, but if he has first applied diagram 58 **he knows what the line-up for his optical system AS IT ALREADY IS should be, and it is important that he have the correct adjustment and correct condenser combination even though he cannot have the correct projection lens diameter.**

The first application of diagram 58 is to show what condenser combination, and what distance from condenser to aperture you should have with the projection lens you are using.

You then apply diagram 58 A and table 8 to find what diameter projection lens you must have to work efficiently, and then, when you have secured the right lens (if you are able to), you apply diagram 58 again to see what condenser combination and what distance you should have from condenser to aperture for the new lens.

With this explanation let us proceed with instructions for

APPLYING DIAGRAM Figure 58. By means of table No. 8 we have shown you how to ascertain what distance is necessary between center of condenser (point midway between the two lenses) and aperture in order that your projection lens admit the entire beam of light from the aperture. Let us now go a step further and, by means of Fig. 58 and 58A, examine and apply what amouts to a universal method for selecting condenser of proper focal length, correct distance center of condenser (point midway between lenses) and proper projection lens diameter.

In Fig. 58 you are to draw each line in its alphabetical order, and make each measurement in its numerical order.

First, on a perfectly smooth, flat table top, spread a sheet of heavy paper suitable to make a drawing on. Light colored wrapping paper, which may be had almost at any store, will do very well, though it will be well to get a kind which will not tear too easily, because you will probaby wish to retain the drawing as a permanent, or at least a semi-permanent part of your projection room records. Fasten the paper down

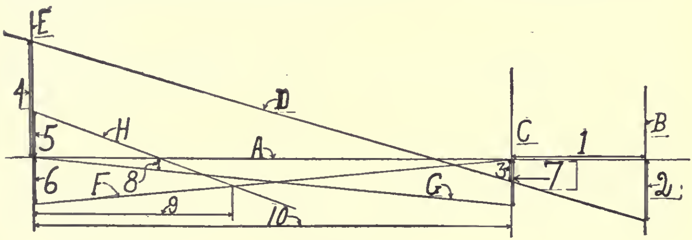


Figure 58

securely, preferably with draftsman's thumb tacks, though of course ordinary tacks will do.

Have the following tools ready: A perfectly straight straight edge not less than two feet long. (A) An ordinary carpenter's steel square will do nicely. (B) A pencil sharpened to a long, slim, flat point. (C) A draftsman's triangle for the purpose of getting lines exactly at right angles to each other, though a carpenter's steel square will serve very well, and two such squares will be excellent. (D) A ruler—the square will serve, if you have one. (E) An ordinary pair of compasses, such as draftsmen use or such as carpenters use. You can make one that will serve very well with two sticks fastened together at one end with a screw and a pin or needle fastened to each of the other ends.

FIRST.—Draw line A, Fig. 58.

SECOND.—Draw line B, Fig. 58, exactly at right angles to line A, and near its right hand end.

THIRD.—Measure distance from your projector aperture at film plane (position occupied by film) to first surface of projection lens—in other words the working distance—when the lens is so adjusted that the picture is in sharp focus on the screen, and at that exact distance from line B draw line C, also at exact right angles to line A.

FOURTH.—Measure the exact free diameter, or opening of your projection lens, and at a point on line B distant from line A the exact diameter of the opening of your projection lens, make a mark. This mark is indicated by the lower point of arrow 2, Fig. 58.

FIFTH.—On line C make a dot one inch below line A. This measurement is indicated by arrow No. 3.

SIXTH.—Through these two points draw line D, as shown.

SEVENTH.—Draw line E at right angles to line A, and at the point where lines A and D are exactly 3.75 (3¾) inches apart, measured vertically. This measurement is indicated by arrow No. 4.

EIGHTH.—1¼ inches above and 1¼ inches below line A make a mark on line E. These measurements are indicated by arrows Nos. 5 and 6.

NINTH.—On line C make a mark 1.25 (1¼) inches below line A. This measurement is indicated by arrow No. 7.

TENTH.—Draw lines F and G, as per diagram, joining the intersection of lines A and E and the lower end of arrow 7 and the intersection of lines A and C and the lower end of arrow No. 6.

ELEVENTH.—Measure the narrowest diameter of your positive carbon crater and, having set your compass to that measurement (you may do it with a ruler, but a compass is much better), find the point on line A where the vertical distance between lines A and G is exactly equal to the crater diameter and make a mark on line A at that point, drawing line H from the point on line E at upper end of arrow No. 5 through the point on line A and on across lines G and F.

TWELFTH.—The distance from line E to the crossing point of lines H and F will be the focal length of each condenser lens required. For instance: If the distance from line E to the crossing point of lines H and F be 7.5 inches, then two 7.5 plano convex lenses will be required.

NOTE.—The combination may, and should be modified as follows: Use a 6.5 inch focal length collector lens and add the difference to the focal length of the converging lens, thus: Suppose the diagram calls for two 7.5 inch lenses. We install a 6.5 plano convex collector lens, which is one inch shorter focal length than is demanded. We then add one inch to the focal length of the converging lens, installing an 8.5 instead of 7.5. Our condenser then is a 6.5 collector and an 8.5 converging lens. The E.F. of a 6.5 and an 8.5 lens is the same as that of two 7.5 lenses.

THIRTEENTH.—The distance from line E to line C will be the correct distance from center of condenser combination (point midway between the two lenses) to projector aperture.

FOURTEENTH. **IMPORTANT.—It must be understood that the foregoing is the correct line-up for the projection lens you have in actual use at the time, and that the condition may or may not be efficient. YOU MUST NEXT** determine what would be the correct (efficient) projection lens diameter under the existing conditions. To do this make a diagram as per Fig. 58 A, which you should keep as a permanent part of the projection room equipment.

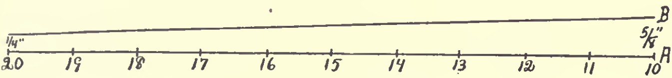


Figure 58 A

Line A, Fig. 58 A must be perfectly straight, and exactly ten inches long. Divide it into inch lengths, by means of dots on or lines drawn across line A, and number the divisions from 10 to 20, as shown, the 20 being always at the left hand end of the line.

Next draw line B, its left hand end exactly ¼ inch from line B and the right hand ends spaced exactly ⅝ of an inch.

Now select one of your positive craters which is of average size, and measure its exact diameter the most narrow way. Set a compass with its points spaced apart the exact distance equal to the crater diameter (compass is not really necessary, but by using it you will get more accurate results) and find the point at which lines A and B, Fig. 58 A, are spaced exactly that distance apart. The distance indicated is used in conjunction with table No. 8, as follows:

Let us assume that the crater diameter fits the spacing of lines A and B at a point exactly over 16. We find the column in table 8 which is headed "16," glance down it until our working distance is reached, and then to the left hand column to get the correct lens diameter.

The next move is to purchase a new projection lens, or lenses, as nearly as possible to the diameter indicated by table No. 8. Next make an entirely new diagram as per Fig. 58, using the diameter of the free opening of the new projection lens for the measurement indicated by lower point of arrow No. 2, Fig. 58. Otherwise the original instructions for making diagram Fig. 58 are not in any way changed.

NOTE.—If it is not possible to secure a projection lens of the diameter indicated by table No. 8, it must be remembered that if your present lens is too small, then any increase in diameter will result in a more economical operation in that it will cause the transmission of a greater percentage of the light to the screen and will give a more even illumination of the screen, hence the effect of greater depth to the picture, always provided the optical system be re-aligned to fit the new lens diameter, as per instructions given.

WARNING.—Diagram Fig. 58 must always be drawn **to fit** the diameter of the projection lens you are now using, regardless of whether the lens is as large as indicated by Fig. 58 A and table No. 8 or not.

When we have finally determined what focal length lenses are required, we go a step further. A 6.5 collector lens will reduce waste between the two lenses of the condenser to a minimum, hence **we install a 6.5 collector lens in all cases, adding the difference to the focal length of the converging lens.** Thus: Suppose we find that two 8.5 focal length lenses are necessary. We establish a 6.5 collector lens, which is (8.5 — 6.5) 2 inches, less than the focal length required. We therefore add 2 inches to the focal length of the converging lens, which makes it a (8.5 + 2) 10.5 lens, so that the actual requirement is a 6.5 collector and a 10.5 converging lens, spaced not to exceed 1/16th of an inch apart. The E. F. of this combination will be the same as the E. F. of two 8.5 inch lenses.

FOR SIXTY AMPERES OR LESS.—We would advise the use of the lens chart, page 191. The use of the diagram Fig. 58 is not advised for anything covered by the lens chart, since the charts are accurately worked out, whereas there is always the possibility of error when using the diagram, especially by those unaccustomed to making drawings and working to fine measurements.

The use of the diagram Fig. 58 sounds quite complicated, but it is really very simple indeed, if followed through step by step.

WARNING.—Projectionists and exhibitors are warned that unless the various elements of the projector optical system be intelligently selected and carefully and intelligently ad-

justed with relation to each other the best results will not be had on the screen. There will not only be waste of light but unevenness of illumination of the screen, with consequent loss of depth, or stereoscopic effect.

CONDENSER DIAMETER.—The diameter of the condenser has an immediate and a very important bearing both upon the amount of light available to the screen from a given amperage, and **upon its quality.**

The large diameter (4.5 inch) condenser in almost universal use in the United States and Canada has very much greater light collecting power than has the small diameter (3 and 3.5 inches) condenser used in some other countries. As compared with a 3-inch lens the 4.5 inch diameter condenser has just about 2 times the area. At first glance we would be inclined to say the smaller lens would, nevertheless, have the greater proportional collecting power because the strongest light flux passes through the center of the lens, but in this we would be either entirely in error, or partially so, because while it is true the strongest light flux strikes at approximately the center of the collector lens, if the crater angle be correct, still the greater area of the outer zones of the collector lens much more than compensate for this, which makes the collecting power of the outlying zones of high value, or would make them of high value were the quality of the light the same for all zones.

The fact is, however, that while the light source delivers light of equal quality to all zones of the collector lens, the heavy angle at which it reaches the outer zones sets up a tendency to chromatic aberration.

The colors thus produced are carried down into the center of the light beam at the spot by spherical aberration, thus reducing the whiteness and brilliancy of the entire spot.

There is, therefore, something more than a possibility that the smaller diameter condenser may after all be as efficient, if not even more so than the standard 4.5 diameter now in use, especially in view of the fact that the crater may be established nearer to the smaller, thinner lens.

Then, too, there is another phase of the subject to be considered, viz., the condition which in itself prevents the use of the full diameter of a standard 4.5 inch condenser. Fig. 59, A is the drawn-to-scale diagrammatic representation of an ordinary plano-convex 4.5 inch diameter condenser, having an actual 4.25 inch free opening, its front surface located 16 inches from the aperture. The projection lens has a working

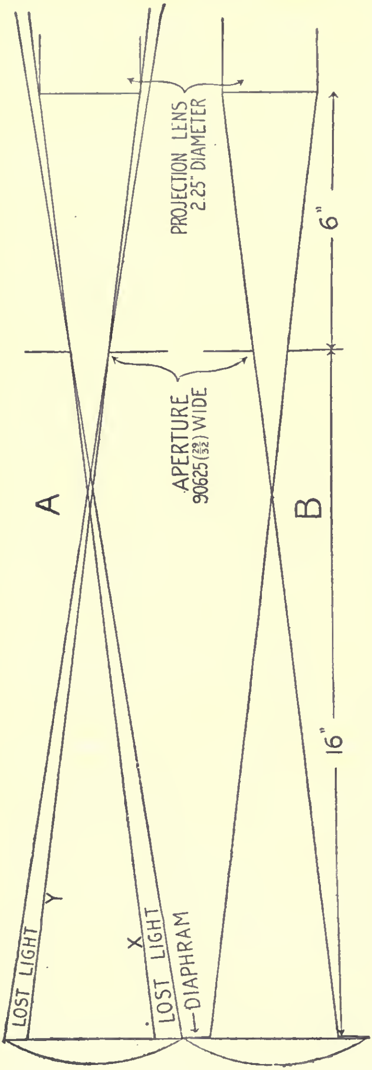


Figure 59.

distance of 6 inches and a free opening of 2.25 inches.

Examining diagram A, Fig. 59, we readily see that, except for light carried down into the effective beam by spherical aberration, no light from the condenser zone labeled "lost light" can possibly enter the projection lens under the conditions shown. It is therefore a fact that under this condition the diameter of the condenser may be reduced without loss of screen illumination, provided the reduction of diameter be not carried beyond lines X-Y of the upper diagram. In fact the reduction will serve a good purpose, as before set forth, in making the remaining beam more white and brilliant at the film plane.

In diagram B, Fig. 59, we see the condenser diameter thus reduced by means of a diaphragm which eliminates the outer zones of the condenser, reducing it to a diameter which enables the projection lens to receive its entire beam. In the condition set forth by diagram A, Fig. 59, the light from the outer condenser zones is worse than wasted, for the above reasons, and for the further reason that, as has already been set forth (see page 182) this condition causes unevenness of illumination on the screen, with accompanying loss of picture depth.

This whole matter forms an interesting field for future study and investigation by projectionists and projection engineers. It is one in which the projectionist using heavy amperage is especially interested, but the local condition must always govern, and whether it is best to reduce the condenser opening, increase the projection lens diameter or utilize the entire ray by applying diagram 58, is something the individual projectionist must decide for himself.

Everything considered we incline to the opinion that the better procedure would be to equip projectors with a standard 4.5 inch diameter condenser, and to add an iris diaphragm by means of which the projectionist may reduce the converging lens opening to fit the local condition.

LARGE DIAMETER CONDENSERS.—Attempts have been made by those not well grounded in projection optics to use a large diameter condenser. A lens even as large as 6.5 inches has been experimented with. It is, of course, quite entirely possible to use such a lens, but in order to use it efficiently the condenser would have to be a great distance away from the aperture. This would mean a long focal length condenser, and the light source would have to be located a considerable distance from the face of the collector lens. In fact, while we have made no actual experiments to determine the matter, we believe that in using the large diameter condenser the necessarily greater distance of the light source from the face of the collector lens would just about be compensated for by the increased diameter of the lens.

On the other hand a lens of this diameter would be comparatively thick, and much more costly. The necessarily greater distance employed between a lens of this diameter and the aperture would make the projector an unwieldly piece of apparatus, which could not be housed in the average projection room as now constructed. Everything considered it is quite safe to say that future procedure will in all human probability tend toward a reduction in condenser diameter rather than an increase.

AERIAL IMAGE—WHAT IT IS.—The aerial image of the condenser is an image of the front surface of the converging lens which is present at a certain point in the light beam.

It is made visible if a suitable screen be held in the light beam at the proper distance from the projection lens.

REVOLVING SHUTTER.—The revolving shutter (see page 611) can hardly be termed anything else than an integral part of the optical system of the projector, since it works in direct conjunction therewith. Its presence, or rather the necessity for its presence, operates to prevent the use of projection lenses of very large diameters. It is not our purpose at this particular place to go deeply into the treatment of the revolving shutter in all its various phases (see page 611), but merely to give you the effect of distance of the shutter from the projection lens.

The shape of the light ray in front of the projection lens varies with the local condition. In the case of a very short focal length projection lens the beam may emerge from the projection lens divergent, the amount of divergence de-

Figure 60.

pending upon the focal length of the lens, or put in another way, upon the projection distance and the width of the picture. With very long focal length lenses the aerial image may be a considerable distance in front of the projection lens, and between the lens and the image the ray may be either parallel or even slightly converging. The correct position for the shutter is at the aerial image, if it is practical to place it there. The position of the aerial image may be determined in a number of ways. It may be found by holding a bit of dark colored paper in the light ray, moving the paper back and forth until a sharp image of the condenser is obtained. When the image is at its sharpest the paper is at the position of the aerial image. Another method is to place a circle of sheet metal or cardboard, in the center of which a hole ¼ of an inch in diameter has been drilled, against the face of the converging lens. Then, first having opened the projector gate and turned the revolving shutter until the lens is open, project the light through and blow smoke in the beam in front of the projection lens.

A point will be found where the light beam will narrow down as per Fig. 60, and the narrowest point of the ray will be the plane of the aerial image. If a cardboard disk is used against the condenser you must work fast when making this test, else the cardboard may get hot, smoke and dirty your lens.

Still another method, and perhaps the quickest and best one, is to project the white light to the screen and then pass a piece of metal or cardboard downward through the light beam in front of the projection lens. If the obstruction is between the lens and the aerial image the shadow will show first at the bottom of the screen, but when the obstruction is made near the position of the aerial image a shadow will appear from both directions, and when these shadows meet exactly in the center of the screen you are obstructing the beam at precisely the plane of the aerial image.

And now, frankly, here is a point on which we are not yet altogether certain. If the beam be parallel from the lens to the aerial image there are those who hold that the revolving shutter may be placed at any point between the lens and the image with equally good results. We, however, hold that the point of the aerial image is better, because at that point a dissolving effect is had, and we believe that this dissolving effect will enable the projectionist to trim down his master blade somewhat more than can be done if the shutter be placed at any other point, even though the diameter of the ray at the other point be equal with the diameter of the ray at the aerial image. We do not make this statement of absolutely known fact, but only as our opinion in the matter.

Note: Under some conditions the aerial image will have greater diameter than the beam at a point nearer the lens. When this is the case it probably will not be advisable to place the shutter at the aerial image. First find out what your conditions are and then use judgment and common sense.

The only benefit in locating the revolving shutter at the narrowest possible point of the light ray, usually the aerial image, is that at that point it is possible to reduce the width of the master blade of the revolving shutter to its lowest possible value, thus allowing the passage of the greatest pos-

sible percentage of the light, and also probably securing a better optically balanced revolving shutter.

PROJECTION LENS DIAMETER AND REVOLVING SHUTTER.—Any increase in working diameter of the projection lens calls for an immediate increase in the width of the master blade of the revolving shutter. This is true even though the smaller lens accommodated the entire light ray, unless the larger lens be diaphragmed down, since that part of the diameter of the lens which is not working will project a halo of reflected light, and that light is often sufficiently strong to cause faint travel ghost unless it be cut off by the revolving shutter. That portion of the edge of the revolving shutter master blade which intercepts light ray runs at a certain given speed at the point it intercepts the light beam, the speed being, of course, dependent upon the distance of the center of the light beam from the center of the shutter shaft. If the light beam be 1.5 inches in diameter, it follows that it will take the edge of the shutter blade traveling at a given speed a longer time to cut through the beam and obliterate the picture from the screen than it would

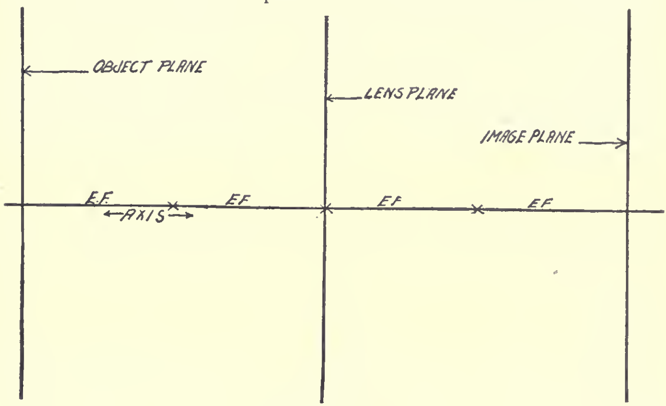


Figure 61.

if the beam were only one inch in diameter, and if the beam be 2.5 inches in diameter there is a decided difference in the time requirement as against the beam 1.5 inches in diameter. It must be remembered that in any event the revolving shutter eliminates approximately 50 per cent. of the total light passing through the aperture. This does not mean that

50 per cent. is eliminated by the master blade, but by the master blade and the other necessary shutter blades. It is highly desirable to get all the light through to the screen that it is possible to get without setting up travel ghost or other injurious effects, therefore the projectionist should study

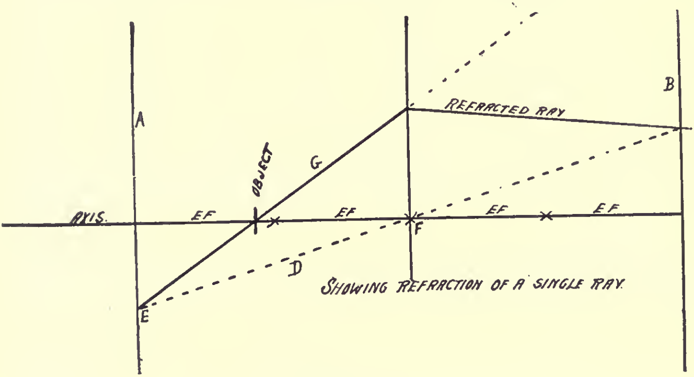


Figure 62.

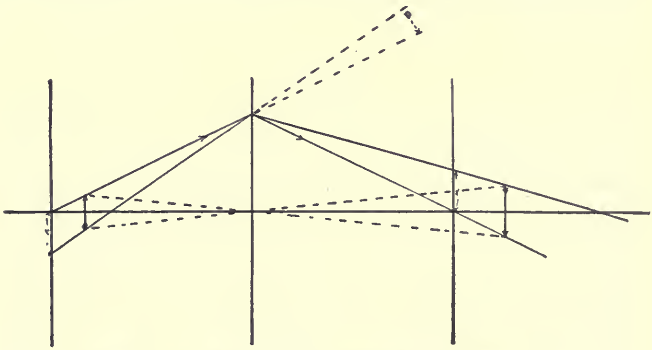
his local condition carefully and ascertain any possibility there may be for improvement through altering the distance of the revolving shutter from the projection lens. We cannot well do more than give you an outline of the problems involved, because as we said in the first place, local conditions vary so much that the projectionist himself must be depended upon to determine what is best in his own individual case. However, unless he himself thoroughly understands the problems involved he cannot do this and will in consequence probably have his revolving shutter working inefficiently as regards the amount of light delivered to the screen; also he very possibly will have a worse condition as regards flicker than he need have.

TO TRACE LIGHT RAYS THROUGH LENSES.—We may be criticised for attempting to teach the projectionist such things as this. If so we have no apology to offer. The projectionist is forced to use directed light—rays directed by lenses—in his profession. The steam engineer who does not understand the action of steam, and who could not trace its action under any given set of ordinary circumstances, would be immediately set down as an ignoramus. He would be ridiculed by his brother engineers, and rightly too. He uses steam. He should understand it. The projectionist uses lenses and refracted light. He should understand them.

More and more we are becoming convinced that there is no more real mystery about light action than there is about steam. Opticians like to make a mystery of their profession. It is remunerative for them to do so. They insist that even the most simple problem in light action be worked out by a very wonderful and intricate process.

John Griffith has evolved a method of tracing light action through lenses which we would ask that you examine with an open mind, remembering that, as Griffith aptly says, while it may not be scientifically correct, it nevertheless IS PRACTICAL; also, it is a thing any of you may understand and apply in practice.

GRIFFITH'S PLAN.—By experience we have found that approximately correct results may be obtained when a set of simple lenses, such as a condenser combination, is under



SHOWING THE REFRACTION A BUNDLE OF RAYS THROUGH ONE POINT OF THE LENS

Figure 63.

consideration, by considering the center of power of the lens, or the combination, as being a single plane.

Let us, for example, select a bi-convex lens. In scientifically correct procedure there are two planes from which measurements should be made, but we may, nevertheless, for the sake of convenience, consider the center of the lens as a single plane from which a single measurement may be made. True, there will be some error incident to this method of procedure, but it will be negligible as compared to the error due to spherical aberration.

The same plan applies to a plano-convex condenser combination. There are in fact two distinct planes from which measurement should be made, but a single plane located at a

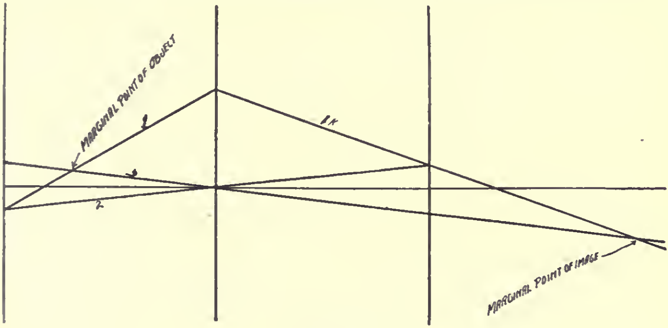


Figure 64.

position between the two real planes which will vary with the radius of the convex surfaces of the lenses, will serve. This plane will be nearest the surface having shortest radius.

Very unscientific, yes, but it is **practical,** while the scientific method of two measurements is not practical, unless spherical aberration be taken into account, a thing we have yet to see any of the scientific men even attempt to do.

There are 2 rules in optics to which attention is directed, viz.: (A) When the object and image are both located at a distance from the lens plane equal to twice its E. F. they will be equal in size. (B) The relative size of object and image are in proportion to their respective distances from the lens plane.

It may be assumed that most opticians are familiar with the wording of these rules, but how many of them have reasoned out what the rules really mean? How many of them realize that rule A means that, no matter where the object and image may actually be, there are always two planes, located a distance equal to 2 times the E. F. of the combination (or the focal length if it be a single lens) on either side of the lens plane, and that these planes are exact duplicates of each other, except that one is inverted. Yet if rule A is correct, this must be true. By this we mean that if a ray passes through or reaches a certain point in the image plane (see Fig. 62) after refraction, its incident direction must be along a line which will pass through the point in the object and a point in the object plane (see Fig. 61) the same distance from the optical axis that the refracted line passed through the image plane, although the ray may actually have its origin on either side of the object plane and at any practical distance from the object plane.

It is thus seen that if we desire to trace the path of any particular ray in a diagrammatic way, as illustrated in Fig. 62, we would first ascertain the E. F. of the combination, or the focal length if it be a single lens, and would establish lines A-B, Fig. 62, distant from the lens plane by twice the E. F. or focal length of the lens combination. We would then draw a line through a point of the source to some point of the lens plane and would continue the line to the object plane. If we then draw broken line D, Fig. 62, joining points E and F, and continue it through the image plane line, we have but to draw a line from the point where line G joins the lens plane, to and through the point where broken line D joins the image plane, to have the direction of the refracted ray, which will continue in that exact direction until it is intercepted.

Fig. 61 shows how to lay out the diagram, both object and image planes being twice the E. F. of the lens from the lens plane, and parallel thereto. Fig. 62 shows how a single ray is refracted.

Fig 63 shows how a bundle of rays are refracted, and Fig. 64 illustrates the method of finding the image of any point of the object.

First draw line 1, Fig. 64, through a point in the object, and continue it until it joins the object and lens planes. Having thus established the point in the object plane, we next draw a line from it to the image plane, so that it passes through the optical axis line at the lens plane. This is line No. 2 in Fig. 64, and gives us the point of the image plane through which the refracted ray, 1-R, Fig. 64, will pass, whereupon a line, No. 3, Fig. 64, drawn through the object point and the lens plane at the optic axis, and on to the point where it meets refracted ray 1-R will indicate the image point. The terms Object and Image planes are used merely to identify the planes as shown in Fig. 61. And it should be distinctly understood that the object and image plane herein referred to have nothing to do with the position of the actual object and image.

It will apply to either single lenses or simple combinations.

Projection

UNDER the broad term "projection," many things are grouped. After the work of the actor, the director, the cameraman and all those other various ones having to do with the production of the photoplay is finished, the product only has commercial value when it is finally presented to the public on the screen.

Presentation of the photoplay and projection of the photoplay are terms with entirely different meanings. Projection includes only those actual things necessary to the placing of the picture on the screen. Presentation of the photoplay includes its projection and all those various things which go to (a) make the theatre patron comfortable; (b) to properly synchronize appropriate music with the picture; (c) to make the surroundings pleasing; (d) to make proper lighting of the auditorium, and in fact all those various things which go to make the finished whole pleasing to the audience.

It is only with projection that we are, however, concerned. We believe there are very few who realize to what an extent the whole motion picture industry rests on the final act of projection. It may be stated as an incontrovertible fact that the success or failure of any photoplay, insofar as concerns any individual audience, will to a very considerable extent rest upon the excellence of its projection. We do not believe any person conversant with the facts will dispute the statement that inferior projection will mar the production—make it less pleasing to the audience. Nor do we believe anyone will dispute the proposition that the more pleasing the screen results, entirely aside from any merit it may have as a play, or the "pulling power" of the artist therein, the greater will be the patronage of the theatre.

On the other hand certainly no one will even question the statement that a dim, "fuzzy," unsteady projection of a photoplay will be far less pleasing to an audience than will a perfect projection.

Most of the readers of this book have visited theatres where the projection is very good indeed, and have also visited theatres where the projection is very poor indeed. You all know what the relative effect of those two conditions would be as applied to any given production—what effect it would have on the "pulling" power at any given theatre.

Summed down, this all means that careful, intelligent work in the projection room brings added dollars in the box office, and unintelligent, slovenly work in the projection room means loss of money to the box office.

To put perfect projection on the screen and keep it perfect during even one entire reel requires ability and knowledge. It also requires ceaseless vigilance and artistic sense of high order.

Not only must the projector mechanism and optical train be kept in perfect condition, but also all other machines and projection room equipment must be maintained in like condition.

The actual mechanical knowledge required to accomplish this is considerable, the necessary electrical knowledge covers a wide range, and the optics of projection are quite sufficient to keep any man busy studying for an extended period of time.

As a matter of fact the modern high class projectionist must have comprehensive electrical knowledge covering dynamos, motors, transformers, mercury arc rectifiers, wire systems, magnetic action and many other things. He must have an accurate knowledge of the electric arc and its action. He must be a mechanic of no mean ability, because he is handling a high speed mechanism which must be accurate in its vital parts within 1/10,000 th of an inch. He must have a very good grounding in optics, and must understand lens action thoroughly. In addition to all this he must be able to judge naturalness of action in any moving object.

REDIRECTS PHOTOPLAY.—A no less person than D. W. Griffith is credited with having made the following statement: "The projectionist in a large measure is compelled to redirect the photoplay." This is not intended as a verbatim repetition of Mr. Griffith's words, but it is in effect what he is credited with having said. The statement attributed to Mr. Griffith is entirely correct, because by a change in the speed of projection the projectionist is enabled to alter the whole effect of any given scene, insofar as concerns the audience. For instance, a funeral procession projected at excessive speed becomes farcial and ridiculous. On the other hand, a race projected at a too-slow speed is absurd. These are two extremes, but the relative effect is there in any sort of scene projected at wrong speed. Actors and actresses are paid huge sums on the presumption that they can enact a given scene in the most artistic way. Is it not then just plain common sense that the best possible effect will be had if the action of these artists be portrayed on the screen faithfully, exactly as they were in the original?

The theatre manager often excuses over-speeding of projection with the statement that he wants to "put pep" into his show. God in heaven! Imagine the manager of a "store room" theatre in Kalamazoo, Missouri, undertaking to "put pep" into Clara Kimball Young or Mary Pickford, or improving on the portrayal of a scene by Earle Williams or William Hart. **Could anything be more ridiculous?** Put in another way, when the theatre manager makes a statement of that kind he simply says in effect, "I know more about how that scene ought to be acted than does the artist who acted it and the director who planned it."

PROJECTION HAMPERED.—In all but a comparatively small number of theatres, projection is more or less hampered in various ways. First, there is the iron-bound, unelastic "schedule," from which the projectionist is not permitted to vary. The manager very naturally desires to start his show at a given time, and have it end at a given time. This is, of course, very necessary, but while the average

NOTE (1) THE TIME PER REEL IS APPROXIMATE AND MAY BE VARIED BY PROJECTIONIST, BUT THE TIME PER SHOW, MUST BE KEPT WITHIN SCHEDULE LIMITS AS SHOWN
NOTE (2) IF SLIDES ARE USED THE TIME IS INCLUDED IN THE SHOW.

12 TO 11 P.M.

NOTE (3) WHEN RUNNING 4½ & 5½ SHOWS BEGIN WITH FEATURE, MAKING TIME AS SCHEDULED WHEN RUNNING 6½ SHOWS BEGIN WITH THE FEATURE, PROVIDED THERE ARE NOT MORE THAN 5 REELS TO FEATURE.

TIME PER SHOW

No. REELS	3 Hrs. 40 Min	2 Hrs. 45 Min	2 Hrs. 27 Min	2 Hrs 12 Min	2 Hrs	1 Hr. 50 Min	1 Hr. 41 Min.	1 Hr. 34 Min
	12.00-3.40 3.40-7.20 7.20-11.00	12.00-2.45 2.45-5.30 5.30-8.15 8.15-11.00	12.00-1.12 1.12-3.39 3.39-6.06 6.06-8.39 8.39-11.00	12.00-2.12 2.12-4.24 4.24-6.36 6.36-8.48 8.48-11.00	12.00-1.00 1.00-3.00 3.00-5.00 5.00-7.00 7.00-9.00 9.00-11.00	12.00-1.50 1.50-3.40 3.40-5.30 5.30-7.20 7.20-9.10 9.10-11.00	12.00-12.54 12.54-2.35 2.35-4.16 4.16-5.57 5.57-7.38 7.38-9.19 9.19-11.00	12.00-1.36 1.36-3.10 3.10-4.44 4.44-6.18 6.18-7.52 7.52-9.26 9.26-11.00
	(3) SHOWS	(4) SHOWS	(4½) SHOWS	(5) SHOWS	(5½) SHOWS	(6) SHOWS	(6½) SHOWS	(7) SHOWS
(7)	—	—	—	—	—	15.7	14.5	13.5
(8)	—	—	—	16.5	15	13.7	12.7	11.8
(9)	—	—	16.3	14.7	13.3	12.2	11.3	10.5
(10)	—	—	14.6	13.2	12	11	10.1	9.4
(11)	—	15	13.3	12	10.9	10	9.2	8.5
(12)	—	13.7	12.2	11	10	9.2	8.5	—
(13)	—	12.7	11.3	10.1	9.3	8.5	—	—
(14)	15.7	11.8	10.5	9.4	8.5	—	—	—
(15)	14.6	11	9.7	8.8	—	—	—	—
(16)	13.7	10	9.1	8.2	—	—	—	—
(17)	12.9	9.7	8.6	—	—	—	—	—

TIME PER REEL IN MINUTES

L. DAVIS 181 E. 104 ST. N.Y.C.

Figure 64A.

manager wants the result, he is not willing to do the preliminary work necessary to enable the show to be run to schedule without injury. In Fig. 64A the effect of certain things is visualized. In this diagram, which is the work of L. Davis, projectionist, New York City, we see the effect of running to schedule with varying footage. For instance, having a seven-reel show, lasting one hour and fifty minutes, it will be necessary to run at an average of 15.7 minutes to the reel, whereas if the number of reels be increased to 9 then the speed would be an average of 12.2 minutes to the reel. And right there comes the abuse of the schedule. The manager has a fixed schedule of, let us assume, 2 hours. Today he has a show of 8 reels, which will be an average of 15 minutes to the reel, provided the whole time be given over to projection. But tomorrow an extra scenic is shoved in. The schedule remains fixed, but the time is, by this procedure, automatically speeded up to 13.3 minutes per reel.

Where a fixed schedule is employed, there is and can be but one proper procedure, viz: the show must first be projected at proper speed, the required time for such projection noted, and enough taken from or added to the program to enable the projecting of the show at proper speed in the limits of the schedule. This is one of the big vlaues of tableau, orchestras and prologues. They can be utilized to fit the show to the schedule, which cannot always be done where the show is entirely photoplay.

OVER-SPEEDING.—One of the cardinal sins of the theatre is over-speeding projection. Former President Wilson once said, within hearing of the author: "I have often seen myself in motion pictures, and the sight has made me very sad. I have wondered if I really do walk like an animated jumping jack, or move around with such extreme rapidity as I appear to."

President Wilson did not know what caused it, but you and I do. It was over-speeding of projection. Over-speeding (a) increases the speed of action of all moving things; (b) sets up heavy strain on the entire projector mechanism and on the sprocket holes of the films. **Over-speeding is reprehensible from any and every viewpoint. It is practiced by managers and projectionists who have no respect for the property entrusted to their care and no adequate conception of the business of exhibiting motion pictures or of their duty towards their patrons.**

Over-speeding projection produces a ridiculous travesty on the original, the amount of which will depend upon the rate of over-speeding. There are managers and projectionists who talk learnedly about a reel requiring "15 minutes" or "18 minutes," in blissful ignorance of the fact that their words convict them of having slight adequate knowledge of artistic projection.

As a matter of fact in any given production the speed of projection is likely to vary with individual scenes, and, as a whole, with individual reels.

The correct speed of projection is the speed at which each individual scene was taken, WHICH SPEED MAY, AND OFTEN DOES, VARY WIDELY.

A cameraman out on location encounters bad light conditions. He slows down camera speed to the limit, in order to get all the light he can. The next scene to this was perhaps taken in a studio, with perfect lighting conditions and at maximum speed. One may have been taken at 60 and the other at 70. **It requires no extraordinary brain power to understand that if the projector pounds along through both scenes at 60, one scene will be correctly portrayed and the other will be entirely too slow,** or if the projector runs at 70 one will be correct and the other entirely too fast. On the other hand, if the projector runs both at 65 then both will be wrong.

One of the highest functions of projection is to watch the screen and regulate the speed of projection to synchronize with the speed of taking.

Of course if cameramen always took scenes at one speed, all that would be necessary to perfect speed of projection would be to set the speed projector at camera speed, but the fact of the matter is THERE IS NO SUCH THING AS A SET CAMERA SPEED. Camera speed varies all the way from 60 to as much as 85.

The projectionist who regards the finer details of projection as not of sufficient importance to justify him in giving them attention is not, and in our opinion never will be, a high class man. Nor is the projectionist excused by the fact that many managers impose schedule limitations which render high class work impossible, or in other ways hamper his work.

Many managers do impose conditions which render high class work impossible, but the fact remains that the man who persistently and consistently bends every energy to improve his projection in every possible way is, in the end, bound to win. It may and probably will require considerable time; it may be discouraging, but success will finally come, and with it, at least in some degree, financial reward.

The manager who employs a high class projectionist, pays him an adequate salary, provides him with good working conditions, tools and supplies, and insists on high class projection, may not immediately see the benefit. The fact remains, however, that in due course of time the public will recognize the fact that in a certain theatre they are sure to see a perfect screen result and other things being equal the effect of this will be made visible at the box office.

We might expend pages in setting forth interesting and valuable matters pertaining to the broad subject of projection, but inasmuch as space is limited, and the whole book is really devoted to that subject, we will end by saying:

Over-speeding the projector is an outrage on the public; an outrage on the producer; an outrage on the projector manufacturer; an outrage on the film exchange and an outrage on the projectionist himself. There is and can be no excuse for it—absolutely none whatever. If the house is full and a crowd waiting to gain entrance it would be far better to eliminate one reel of the program than to butcher the whole performance.

THE MAN WHO DOES NOT BELIEVE IN THE VALUE OF EXPERT KNOWLEDGE IS AN EXPENSIVE EMPLOYE AT ANY PRICE.

The Screen

THE sole and only function of the screen is that of reflecting "picture light." The eye sees the picture precisely for the same reason it sees any other visible object. Exactly as light rays are reflected from any visible object to the eye, so in projection light rays are reflected by the screen surface to the eye. The picture appears plainer, sharpr and in every way better if the picture light be abundant—the screen brilliantly illuminated—than if it be dull, or if light other than picture light be also reflected.

The term "picture light," as used here, may be understood as meaning light projected to the screen from or by the projection lens; "other light" is light reaching the screen from sources other than the projection lens, which latter, being undirected by the lens, shines indiscriminately upon both whites and shades of the picture, thus dulling the contrast and causing the blacks to appear gray.

There is a great difference in screen surfaces and the results had from different ones with a given intensity of picture light. This is likely to be especially true when the screen be viewed from various parts of an auditorium, but until quite recently there has been no dependable, authoritative data setting forth the characteristics of various surfaces used for projection. The author had in mind the making of certain measurements and tests for this edition of the handbook, and had in fact already done considerable preliminary work thereon when the Society of Motion Picture Engineers made available tests of screen surfaces which made that work on our part unnecessary. We were well pleased with this, partly because of the tremendous amount of work involved in the making of such tests, but even more because such data should come from just such a source as the Society. We shall present the tests and the conclusions arrived at, page 259-267. They have real value in that they enable exhibitors and projectionists to work intelligently in the matter of selecting screen surfaces for auditoriums of various depths and widths.

A FALSITY.—In the past many exhibitors and projectionists have based their judgment of the efficiency of various screen surfaces on looking at the performance of screens in different theatres.

This is an utterly unreliable test, because it almost never happens that there are two screens in neighboring theatres where the various factors which may affect the result are of equal value, and the working conditions precisely alike.

In any two theatres the brilliancy of projection light may, and in all human probability will, have different value, because of differences (a) in amperage at the arc, (b) in crater angle, (c) in the carbons themselves, (d) in the condensers or their spacing or discoloring, (e) in the general adjustment of the optical train, (f) in the projection lens diameter or working distance, and (g) in the revolving shutter.

The result may also be very much altered by the decorations of the theatre, by its lighting, by the number and arrangement and power of the orchestra lights, by the screen surroundings, the screen border, the shape and height of the auditorium, size of the picture, angle of projection, etc., etc., through a long list.

In fact the things affecting apparent screen brilliancy in any given theatre are so very many that the judging of relative screen values by observing the picture in various theatres is an utterly futile endeavor.

It is even impractical to judge closely of values by substituting one screen surface for another while a picture is running, because of possible differences in light values. Suppose we run half a picture on one screen and then drop another down to receive it, but the crater angle has, unknown to even the projectionist, changed, or the supply voltage has dropped, thus altering the light brilliancy considerably.

The only way such a test can be made with any assurance of reliable results is to cover half the screen with the surface it is desired to test, and then project a picture, **observing results from all parts of the theatre.**

This is a test which is in every way fair; also it is not a difficult one to make, but exhibitors and projectionists should remember that it is not to be expected that the surface of a screen which has been in use for a considerable time can enter into successful competition with a new surface.

We would most emphatically warn exhibitors, projectionists and theatre managers of the danger of judging hastily as between various screen surfaces. We would also caution

exhibitors, managers and projectionists against the too ready acceptance of statements made by screen salesmen.

Those gentlemen are employed to sell goods. Their job depends upon their ability to do it, and we have known of cases where they did not confine their statements as to the merit of their own goods vs. the screens made by others to quite the exact facts.

We have known of many cases where exhibitors have paid substantial sums of money for new screens which were in fact inferior for use in their theatre to the screen the new one displaced. In such cases the exhibitor might better have taken his money out and scattered it in the street.

It is a part of the duty of projectionists to study screen surfaces and be able to advise the theatre management intelligently in such matters.

We would advise exhibitors to under no circumstances purchase screens until they have first carefully examined the various charts and tables herein contained, and ascertained the characteristics of such surfaces, subject only to later, amended data published from time to time in the projection department of the Moving Picture World.

If for any reason it is not deemed expedient or advisable to follow the foregoing advice, then we would advise against the purchase of any screen until the maker or dealer has covered half your theatre screen with a sample of the surface he is selling.

There is absolutely nothing impractical in the latter. It is quite possible for a screen salesman to carry a sample of that size. Once such a sample is in place it is very essential that the result be viewed from every portion of the house, including the balcony, if there be one.

Don't attempt to judge from a small sample. Unless you can determine the characteristics of the surface under consideration by the tables and charts submitted herewith, oblige the salesman to cover half your screen, or else escort him to the front exit and bid him a polite but firm good bye.

As already set forth, the only function of the screen is to reflect light. It therefore follows that in order to understand the results emanating from any given screen surface we must first understand a few of the many laws which govern light action.

SPEED OF LIGHT.—Light travels at the terrific speed of 186,000 miles per second, a speed so tremendous that there is no way of controlling it, hence light speed has a fixed value which cannot be altered. This item is of no particular interest to the projectionist, except as a matter of general information.

REFLECTION; DIFFUSE, SEMI-DIFFUSE AND REGULAR.—There are three kinds of reflection, viz., regular, semi-diffuse and diffuse. Regular reflection occurs when light strikes a smooth, polished surface, and is not broken up and scattered. An example of regular reflection is the ordinary mirror, in which we see ourselves because light is reflected from the surface of our face to the glass, and by the glass is reflected back into our eyes without being scattered or diffused. This type of reflection is illustrated in Fig. 65.

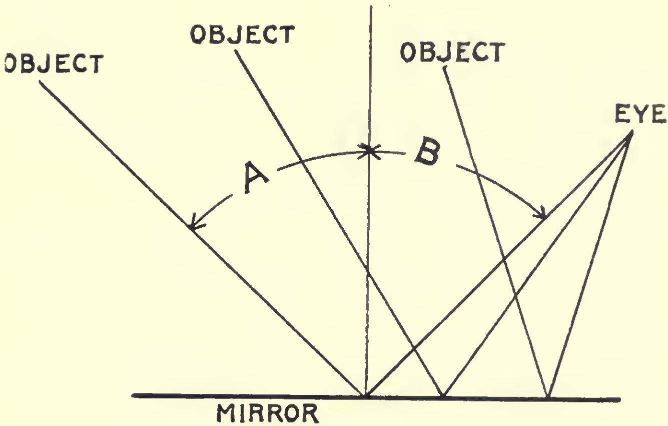


Figure 65.

In regular reflection angle A is always equal to angle B. Angle A is the "angle of incidence"; angle B the "angle of reflection."

Diffuse reflection occurs when light is reflected to the eye from a body which has a roughened unpolished surface, which by reason of its roughness, scatters or diffuses the light rays. The more evenly the light is scattered in all directions the more perfect is the diffusion said to be.

It must not be understood from this, however, that by roughness we necessarily mean a surface which appears rough to the eye. The roughness we have reference to is termed "peaks and depressions," and these peaks and depressions may be very minute in size. Smooth plaster is a perfect diffusing surface, although it appears smooth to the eye and feels smooth to the hand. It is diffusing, however, because it is not a polished surface, but a surface made up entirely of peaks and depressions of sufficient area to break up the light. The effect of such surfaces is illustrated in Fig. 66.

"Picture Light" projected upon a screen is reflected from its surface back and is scattered in a wide or narrow angle, exactly in proportion to the completeness with which the surface lacks polish and is made up of peaks and depressions.

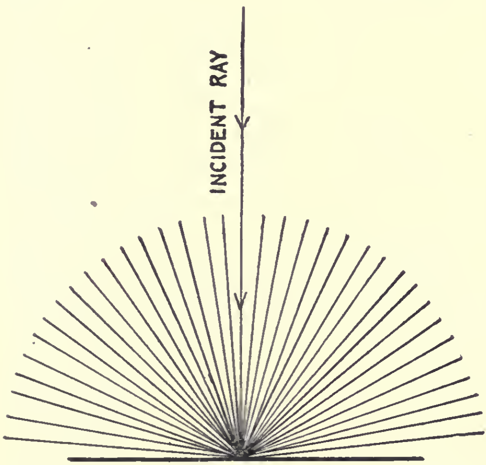


Figure 66.

Light rays and the elements of the screen surface which scatter them are both of an almost infinitely small dimension.

HAZE.—Some surfaces which have been used for screens have to a certain extent both the elements of polish and of peaks and depressions. Such screens provide both regular and diffused reflection, with the result that a haze appears before the screen. This haze is the result of regular reflection superimposed over or upon the diffused reflection. It is a peculiarity of the polished metal surface screen, and explains the reason for the failure of many homemade metallic projection surfaces.

VISIBLE ROUGHNESS.—It was for a long while believed that screens with surfaces visibly rough had advantage over smooth diffusing surfaces, such as plaster hard finish. This has been proven to be an error. Always providing the surface be of a character to give a high degree of diffusion there is no added advantage in visible roughness.

INTERFERING LIGHT.—One of the very worst faults encountered in motion picture theatres, insofar as has to do with the screen, is interfering light. By this we mean any light other than picture light which strikes the surface of the screen. Light interference may be caused by (a) stray beams from the projection room which strike the wall or ceiling of the auditorium, and are by them reflected to the screen. These rays usually come from the condenser. Their elimination is a very simple matter. (b). Daylight, which is a most prolific cause of poor results at matinee performances. It is nothing short of astounding how little attention theatre managers and projectionists pay to the thorough excluding of daylight from the auditorium at matinee performances. Any daylight which reaches the screen, no matter how slight, is highly detrimental to the picture. This is such a patent fact that it would seem any projectionist or theatre manager would realize and understand it. (c) General auditorium lighting improperly arranged or improperly shaded. This is another point concerning which many theatre managers display an absolutely incomprehensible indifference. We have many, many times entered theatres of considerable pretension, which charged a top notch admission price, and found the auditorium lights literally murdering the picture, or, **what is equally bad,** found unshaded white or brilliant red lights glaring directly into the eyes of the audience. Auditorium lighting will be discussed under the proper heading, therefore we will not go into it further here.

Exhibitors and projectionists should test their screen for stray light occasionally. They may only do this best when the projector is not working, and the theatre is lighted just as it is when the show is on, including the musicians' lights.
In regula **this condition the screen does not look the same all**
the "angle of **absolutely no trace of shadows or bright spots,**
Diffuse reflec **omething wrong, and the offending light or**
eye from a body wh **shadows or bright spots should receive**
which by reason of it
light rays. The more een thus, with the entrance doors
directions the more perfec whether bright spots or shadows
It must not be understo s latter test should be made in
roughness we necessarily n e evening if there is a matinee
rough to the eye. The rough of the entrance doors affects
termed "peaks and depressio cessary to protect the screen
pressions may be very minut

from the light entering through the open doors should be taken.

Exhibitors who pay perhaps hundreds of dollars a week for film service, and who fail to give proper attention to such details as these are doing a very foolish thing. They are not getting the best possible results from the film service they are buying. They should remember that anything which affects the screen result to its deteriment tends to lower box office receipts. **Most emphatically a screen which is struck by any light other than the picture light itself does not give the best possible result.**

Small town theatres which have windows opening directly outdoors may exclude the light effectually by means of double, dark colored window shades, the edges of which run in grooves not less than one inch deep. These grooves may easily be built by a carpenter, and the plan will be found quite effectual. One shade will do, but two are better, since the single shade is likely to develop pin holes which will admit light.

Standing beside the screen, looking toward the auditorium, there should be no unshaded light source visible to the eye at any point. If there is, then the light from that source is reaching the screen and injuring the result.

Indirect lighting is a most excellent form of auditorium illumination, provided it be properly installed, but this is by no means always done, the most common fault being the installation of fixtures too close to the screen end of the auditorium.

Reasonably dark colored, non-reflective wall decorations are a great aid in eliminating stray light; also they are very restful to the eye, though by this we do not mean to infer that the decorations of a theatre should be sufficiently dark colored to be gloomy.

DISTRIBUTION OF REFLECTED LIGHT.—One fundamental requirement of a screen surface is that it as nearly as possible reflect light equally to all seating space in the auditorium, so that the picture appear as brilliantly lighted to those patrons seated at a heavy angle to the screen, or to those seated in the balcony, as it does to those seated in the center of the orchestra floor. If the screen exhibits a certain degree of brilliancy to those seated in the center of the orchestra floor, and a lesser degree as one moves around to one side of the house, it is said to have "fadeaway," and just in proportion as the screen develops this characteristic it is a poor diffusing surface. If the fadeaway be too pronounced it is not a good surface to employ for a screen, except in the case of a very narrow auditorium, no matter how convincingly the screen salesman may talk in the endeavor to convince you to the contrary. It gives semi-diffusion of the light, as per Fig. 67.

SEVEN CLASSES OF SCREENS.—Screen surfaces may be divided into seven general classes, viz.: (1) white wall, (2) the cloth screen, (3) the kalsomine screen, (4) the painted screen, (5) the metallized surface screen, (6) the glass or mirror screen, and (7) the translucent screen.

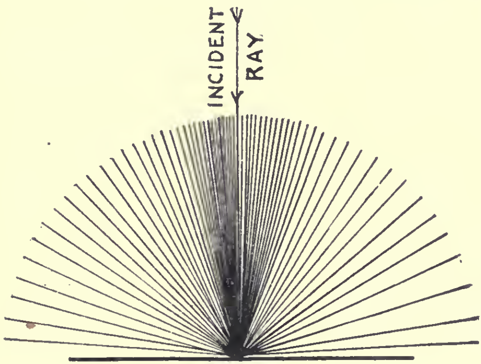


Figure 67.

Semi-diffuse reflection, in which the greater part of the light is reflected back in the direction whence it came.

THE WHITE WALL. — The white plaster wall known as the "hard finish surface," forms an excellent surface for the projection of pictures, in that it has very excellent diffusion indeed, while at the same time its power of reflection is good for a surface of such high power of diffusion. The plaster surface may be cleaned by sand-papering it lightly, using No. ½ sand paper, but it can, of course, only be cleaned a limited number of times before it will be worn down to the brown plaster underneath.

THE CLOTH SCREEN.—This has as excellent powers of diffusion as any surface procurable but its power of reflection is very low. It is, therefore very difficult to get a brilliant picture of a theatrical size on cloth. The cloth screen is now seldom used except for strictly temporary installation, or by traveling exhibitors. If it is proposed to use cloth a good grade of bleached muslin of the kind used for bed sheeting is best. It is possible to obtain this cloth 108 inches in width. A cloth screen should always be tightly stretched, so that it will present a smooth, unwrinkled, perfectly flat surface.

THE PAINTED SCREEN.—There are certain things with relation to paints which have been thoroughly established by experiment. but which have not as yet been put into form for application in practice insofar as applies to the projection surface.

The higher the percentage of pigment contained in a paint the higher will be its light-reflecting power. Experiment has proven that it is quite possible to produce a paint of extraordinary whiteness and very high light reflecting power by using heavy bodied oils, cut down by means of volatile thinners. It is claimed that by this method flat paints may be had which will have from 20 to 25 per cent. higher light reflecting power than paints now in general use.

In ordinary inside house painting it has been found that lead and oil paints deteriorate in light reflecting power by about 15 per cent. per year, aside from the loss of reflecting power due to accumulations of dirt—due entirely to chemical changes in the paint itself.

It has also been found that kalsomines lose in reflection power in about the same ratio, but in this case it is entirely chargeable to absorption of dirt by the porous coating, hence the loss will be very much higher in a dusty or smoky atmosphere.

WARNING.—Black should never be used to "whiten" screen paint, because the addition of the least bit of black acts to seriously lower the reflecting power of the coating.

The foundation for a painted screen surface may be tightly stretched cloth, cement finish, plaster, or anything else which presents an even, unbroken surface. There are a number of screen paints on the market, but up to date (subject to foregoing, which forms basis of interesting study) we have seen nothing better than either all zinc white, or half zinc white and half of a good grade of white lead, mixed to a proper consistency with ¼ boiled linseed oil and ¾ turpentine, adding just enough ultra-marine or cobalt blue to give the paint a very light bluish cast while in the pot. When spread on the surface the blue tint will disappear and the paint appear dead white. Unfortunately, no authoritative data as to its reflective power is available, but it must be decidedly superior to that of white plaster, and paint is as excellent a diffusing surface as any we know of, excepting only plaster and cloth. Colors, of course, may be added to suit the individual idea, but our own advice is to stick to the white paint, without any color of any kind whatsoever. We would advise the application of three or four coats of tolerably thin paint, rather than a less number of coats of heavy paint. The result will be better, and the surface dries very quickly.

The painted screen offers an easily and cheaply renewed surface, very excellent diffusion, practically an entire lack of fadeaway, and the best possible definition of the picture from the front rows of seats. Very many high class theatres either already have or now are reverting back to the painted screen, because of the advantages above enumerated. Everything considered, it forms one of the most excellent projection surfaces yet discovered for theatres when the viewing angle exceeds 30 degrees, though a given amount of light per unit of area will not give as great brilliancy, when the screen is viewed from the center of the auditorium, as will be had when using either a metallic surface or mirror screen.

There is, however, a great deal of what we will call self deception in the matter of screen paints, or rather in the methods of painting a screen. When white paint is applied directly to a cloth screen a great deal of light "goes through." This light is, of course, lost, and in the endeavor to save it some rather weird plans have been evolved. As a rule the idea most advanced is that if a coating of semi-opaque color be applied to the surface, and sufficient coats thereof be applied to make it opaque, and then the white surface be placed over this opaque surface, or even if the opaque coatings be applied to the back of the finished screen, no light will "go through," hence there will be a greater brilliancy. The favorite color for the underlying coatings has been blue, or a sort of lead color, on the theory that the light, striking the blue and being reflected back will whiten the overlying surface.

As to the latter, to an extremely limited extent it might possibly be true, but while the opaque coatings underneath the white will stop the light from going through, it will not and cannot add anything appreciable to the brilliancy of the screen. The underlying coat stops the light from going through for the very simple reason that it absorbs the rays. It does not reflect them back, or anywhere else, modified by the fact that if the underlying coat be blue it will absorb everything but the blue rays, the question then being can the blue ray be reflected back through two or three coats of white paint, or even appreciably through any minimum necessary number of coats. Personally we do not believe it is possible this could take place to a sufficient extent to have any appreciable effect in whitening the surface, and most emphatically it could not add any brilliancy to the screen other than what slight effect there might be in whitening, which latter effect could be just as well secured by adding blue directly to the color.

FOR AIRDOME SCREENS a paint is necessary. If the surface of a theatre screen to be painted be plaster, then it should first either be sized with a coating of glue size, or painted with a coat of thin shellac. If the airdome screen be built of lumber, then we would suggest the installation of a painted cloth screen, stretched on a suitable frame, over the lumber backing.

WASHING PAINT SURFACE.—A painted surface may be washed, provided it be very carefully done, but the washed surface will not have the same brilliancy as a new surface.

KALSOMINE SURFACE.—A variation of the painted screen which we can heartily recommend is the covering of either cloth, plaster or cement with one of the patent white kalsomines, such as alabastine or muralite, which may be had from any dealer in paints, and which may be applied by almost anyone after a little practice, though it is, of course, always better to have the work done by a competent painter. This surface forms a really very excellent screen. In powers of diffusion it ranks very close to white plaster, and while we have no authoritative data as to its power of reflecting light, it should be as high or even higher than that of white plaster.

CAUTION.—In kalsomining one must use a good brush, and make no attempt to brush out the work smoothly. Instead one should swing the brush in every direction. The work must be done fast, because if the edge of the work dries so that the next "lap" will not work into the first perfectly the joint will show. It is better to have kalsomining done by a man experienced in such work.

Don't imagine that you can coat a cloth or plaster screen with kalsomine or paint and use it indefinitely without doing anything more to it. We would very strongly recommend that where a plaster or cement kalsomine coated screen is used, it be washed off and recoated every ninety days.

It may look clean and bright, but you may be very certain it is not. The wall paper or kalsomine on the walls of your home may look perfectly clean, but knead some fresh bread into a dough, rub the wall paper with it and see what happens; perhaps the result will astonish you. Exactly the same thing applies to the screen. Kalsomine or paint is cheap. Our advice is, USE THEM FREQUENTLY.

TESTING SCREEN SURFACE.—To test either a kalsomined or painted projection surface place against it a sheet of white blotting paper—a desk blotter as to size. If the paper appears whiter than the screen, then the screen is not in good condition.

NEAT CEMENT SURFACE.—"Neat" cement is white in color. It has been suggested that it would make an ideal screen surface. This suggestion may or may not have value. We have never seen such a surface, nor have we any data concerning the matter.

GLUE SIZING.—Before undertaking to coat a cloth screen with either paint or kalsomine it must be stretched tightly on a frame and thoroughly sized with a solution of glue in the proportion of from 1 to 2 pounds of glue to the ordinary pail of water. The amount used will depend upon the grade of glue.

METALLIZED SCREEN SURFACES.—Screen surfaces to which various compounds containing more or less powdered aluminum or other powdered metallic substances have been applied, have been and still are quite popular, though the tendency is to revert back to the plain white painted or kalsomine screen, except in theatres having a rather narrow auditorium.

Metallic surface screens have for their base some kind of cloth fabric, to which the metallic substances are applied by processes which are held jealously secret by the manufacturers. Their sole advantage lies in the fact that within certain angles the projectionist is able to get a very high degree of brilliancy per unit of area at considerably less expenditure of light, hence of electric energy, than is possible with a more perfect diffusing surface. This relatively high brilliancy, however, usually only extends over an angle of 20 to 30 degrees, outside of which angle there is a decided fadeaway. See tables 12 to 16 inclusive. There is also a more or less pronounced tendency to discoloration of the surface, especially in damp climates, though this latter fault need not worry the purchaser if he secures a proper **written** guarantee against such fault.

There is a very decided difference in metallic screen surfaces, but the characteristic of the different types may be examined in tables 12 to 16, so that the purchaser may know precisely what effect he will get from any given type of screen.

WARNING.—It is a very difficult matter to apply metals (either in powder or paint form) to a screen surface in such way as to secure the best possible light diffusion, and the exhibitor who prefers to use a metallic surface screen should by all means purchase the screen from a reliable manufacturer. The manufacturer makes a specialty of preparing such surfaces; also he usually applies stretching devices which will allow of the screen being properly installed. It is almost impossible, and certainly is entirely impractical for the projectionist or exhibitor to make a satisfactory home made metallic surface screen.

CHALK SURFACE.—There is possibility for an excellent projection surface in common chalk. This surface has to some extend been used, and has given excellent results. The surface is made by rubbing ordinary white chalk, such as carpenters use for their chalk lines, and which may be had cheaply at any hardware store, on plaster or any other suitable surface. Even school crayons, broken in two and used flatwise, will do. Such a surface costs very little in money, but requires considerable labor to get it on evenly. The picture stands out on a chalk surface with surprising brilliancy.

Rubbed on a plaster wall a chalk surface may be removed for renewal by means of an ordinary school blackboard eraser, and may be renewed by a few cents' worth of chalk, plus considerable labor.

MIRROR SCREENS.—The mirror screen consists of a sheet of plate glass, the back of which is coated precisely the same as is an ordinary plate glass mirror. Its face is then sand-blasted to a dull finish, which may be made rough or smooth, according to the condition under which the screen is to work. The light is caught on the ground face and a portion of it is reflected back. The rest of it goes through, strikes the silver at the rear surface and is reflected back to the rough finish. This has the effect of producing a very high efficiency and a very brilliant result when the screen is viewed from in front; but due, we believe, in some measure to the thickness of the glass, there is tendency to out of focus when a mirror screen is viewed at a wide angle. The satin finish mirror screen is an ideal installation for the long, narrow theatre, by reason of the fact that the audience will all be seated practically directly in front of it, under which condition a very brilliant picture may be had with a comparatively low projection light value; also the satin finish mirror screen has the peculiarity that the further you get away from it, within reason, of course, the more brilliant the picture appears. It is, therefore, particularly of value in a very deep, narrow house.

One of the principal objections to the mirror screen is that it is costly, difficult to install and subject to some, though slight, risk in the item of breakage. Once installed, however, barring very improbable accidental breakage, it should require no attention, except on occasional washing, for many years.

TRANSLUCENT SCREEN.—The translucent screen is either made of translucent material, such as tracing linen, or it is of ground glass. With this type of screen the projector may be located on the side of the screen opposite from the audience, which will view the picture through the screen. The image appears on both sides of the screen, but is reversed to the projectionist, to whom all titles and other reading matter will read backward.

When projecting through a translucent screen (called "rear projection") the film is placed in the projector with the emulsion side toward the screen, instead of toward the light as in ordinary projection.

It is possible to use ordinary cheese cloth or thin muslin cloth for a translucent screen, but if this be done the projection lens must be sufficiently below the center of the screen so that a straight line from the eye of the spectator to the lens will not pass through any part of the picture. In practice this means that such a screen cannot be used for rear projection at all if there is a balcony in the theatre. The reason for this is that any spectator who sits in such position that the eyes will be in line with any portion of the picture and the lens will see the brilliant lens spot through the screen. The ground glass, tracing linen and screens of similar characteristics break up this bright spot and render it invisible.

If a cloth screen be used the result will be greatly improved if it is kept wet with water.

The best screen of all for rear projection is ground glass, because it causes but a comparatively slight loss of light; also it gives very good diffusion, though it is claimed there is advantage in grinding the surface coarse for a wide house and fine for a narrow house.

Tracing linen makes a fairly satisfactory translucent screen, its worst feature being that it cannot be had sufficiently wide, hence the screen must contain a seam which cannot be made invisible by any present known process, and will show more or less in the picture.

Rear projection is, however, but very little used. It presents advantages where conditions are such that it can be properly employed, but in 9 cases out of 10 where it is attempted the distance of projection is so short that really good results cannot possibly be had. In fact rear projection usually is employed as more or less of a makeshift.

Where it is possible to obtain a distance from projector to screen which will admit of the use of a projection lens of not less than 4 inches E. F., however, rear projection on a glass or other high class translucent screen comes pretty near being ideal, since the projection room with its noise, heat and fire risk may be located entirely away from the audience, presumably outside the theatre.

The question is often asked, can we locate a translucent screen at the proscenium line, set the projector at the rear of the stage and get a good picture? The answer is an emphatic no! It is never advisable to attempt the projection of a picture of a size suitable for theatre work with less than 50 feet from the lens to screen, and 40 feet may be considered as an absolute minimum, understanding, however, that real high class results cannot be had at 40 feet unless the picture be smaller than is ordinarily suitable for theatrical work. Another very serious objection to this plan is that it places the screen altogether too close to the front row of seats.

THE CONCAVE SCREEN.—There is no advantage in the installation of a concave screen surface, except possibly in cases where the distance of projection is such that a very short focal length projection lens must be employed—say a lens of less than 3.5 inch E. F. Under such a condition there may be some advantage in a concave screen surface, but given a normal projection condition any advantage such a surface might offer would, in our opinion, be more than offset by disadvantages it would present in other directions. In our opinion where the condition is such that a projection lens of 4.5 inch E. F. or more is required a concave screen presents no advantage whatsoever. It is one of those things which looks very plausible, but which will not stand the cold light of critical analysis.

HEIGHT ABOVE THE FLOOR.—The height of the screen above the floor must, of course, to some extent, be governed by conditions obtaining in the individual theatre. Where there is a stage we believe the general effect will be best if the bottom of the picture be located quite close to the floor. Other things being equal, this we believe, gives the most nearly lifelike effect to the picture.

There is, of course, a distinct advantage in locating the picture high up on the wall. In some countries this is the almost universal practice, the auditorium floor being left perfectly level. Such location, however, also has very serious disadvantages, the principal one of which is the tendency to emphasize in the mind the fact that one is looking at a picture, and not a real performance; this because of the fact that in the home and elsewhere we see the picture hung on the wall, and the mind, to some extent, subconsciously connects the moving picture which is located high up above the floor with the picture on the wall.

Everything considered we believe that, where it is practical, the best general effect will be had by locating the bottom of the picture about 6 feet above the auditorium floor where the screen is on a wall, and no orchestra is used. If there be an orchestra, then it will be better to add perhaps 2 feet to the above, in order to, as far as possible, avoid the effect of the musicians' lights.

EYE STRAIN.—Many people avoid the photoplay theatre either because they have seen motion pictures under circumstances which set up eye strain, or because they fear the motion picture will cause injury to their eyes. Eye strain in moving picture theatres may be attributed to five main causes, viz.: flicker, poor definition, poor illumination, a too large picture, and glare spots.

FLICKER.—It is a fact well understood by most people that the pupil of the eye expands and contracts in direct proportion to light intensity. The retina of the eye is most comfortable and "sees" best at certain given light intensities, which vary considerably with the individual. The office of certain muscles known as the "muscles of accommodation" are to expand or contract the pupil of the eye to let in just sufficient light to maintain the value most comfortable to the retina.

When flicker occurs the tendency of the muscles of accommodation is to open the pupil during the period of darkness to a point where a greater proportion of light enters when the picture is being projected than is "comfortable" to the retina. This causes a distinct shock to the retina. Another effect is a tendency of the muscles of accommodation to follow the rapid alternations of light and darkness, and this sets up a terrific strain indeed.

In this connection let it be clearly understood that when flicker occurs it occurs because of some wrong procedure somewhere in the process of projection. Flicker can always be eliminated by the projectionist if he understands his business, is provided with proper equipment and is unhampered by orders from the management which prevent him from applying the remedy.

The screen itself never produces flicker, but where a screen of comparatively low efficiency is used, and is later replaced by one of the same area, but of higher efficiency, if the same amperage be used the tendency to flicker will be increased by the added brilliancy of the reflected light.

The period of darkness remains of the same duration as to time, but the light is more brilliant, hence there is added contrast. If the light were reduced until the picture on the new screen had no greater brilliancy than the picture on the old screen, which may be done by reducing the amperage, it would be found that the flicker will be neither more nor less than it was before.

Flicker due to the alternate opening and closing of the lens by the revolving shutter of the projector is utterly inexcusable. When it occurs, either the projectionist lacks the knowledge necessary to eliminate it; lacks energy to do the necessary things to eliminate it, or the speed of projection is too slow.

LACK OF DEFINITION AND EYE STRAIN.—Lack of sharp definition in the picture operates to set up heavy eye strain. If you doubt this, have a stenographer do some typewriting, making about four carbon copies on ordinary paper. The last copy will be "fuzzy." Try to read a page or two of that kind of copy and see what happens to your eyes. The writing is out of "focus," very much the same as is a picture on the screen when it lacks definition.

Lack of definition may be due to several things. A poor lens may cause it. A wrongly adjusted optical system may cause it. Oily film may cause it, or the cause may be inherent in the film itself.

In view of the foregoing, and the importance of preventing eye strain in motion pictures now that they have become such an enormously popular form of amusement, the theatre management should expend some energy and money in securing the best possible lenses, the projectionist should thoroughly understand the handling of the optical system of his projectors, and the projectionist who is careless and "sloppy" enough in his work to get oil on the film should be promptly discharged. For a manufacturer to send out film which cannot be projected in sharp definition on the screen is little short of criminal, the crime being against the eyesight of this and future generations.

EYE STRAIN AND POOR ILLUMINATION.—In proportion as an audience becomes deeply interested in the picture story, it will make every effort to catch every phase of the projected picture. It will closely watch every detail of the action, both major and minor, since it sometimes happens that upon some slight change of expression, a side glance or the wink of an actor's eye, or some comparatively slight detail in the action, will hinge very important details of the story itself. The audience, therefore, is anxious to miss nothing, and if the illumination of the picture be not sufficient, it is entirely understandable that comparatively heavy eye strain may be set up.

We read the picture story upon the screen almost exactly as we read the printed page of a book. If we attempt to read a book with a poor light, or when it is shaking or moving (jumpy picture) the result is a strain upon the eyes, which may be entirely avoided by improving the illumination and holding the book still. This is just plain common sense. It is a point which even the most obtuse can readily understand.

Precisely the same thing applies in projection. We improve the illumination by projecting more light to the screen through the film, and instead of "holding the book still,' we prevent the picture from "jumping" on the screen.

EYE STRAIN AND SIZE OF SCREEN.—The size of the screen plays a highly important part in the matter of eye strain. If the screen be too large, or, what amounts to the same thing, if the front rows of seats be too close to the screen, very heavy eye strain will be set up for those occupying the front rows of seats. This is for a double reason. In the first place, due to the excessive size of the screen or the nearness of the seats to it, the eye must travel over a wide surface in following the action. It requires no great wisdom to understand that this in itself is very hard on the eyes. Then, too, if the screen be too large, or if the front rows of seats be too close to it, the tendency to eye strain is augmented, because the picture will not be seen in sharp focus from these seats.

GLARE SPOTS.—One of the most prolific sources of eye strain is what is known as "glare spots," which means a relatively small spot which is highly illuminated as compared to its surroundings, and which falls within range of the eye of the theatre patron who is looking at the screen.

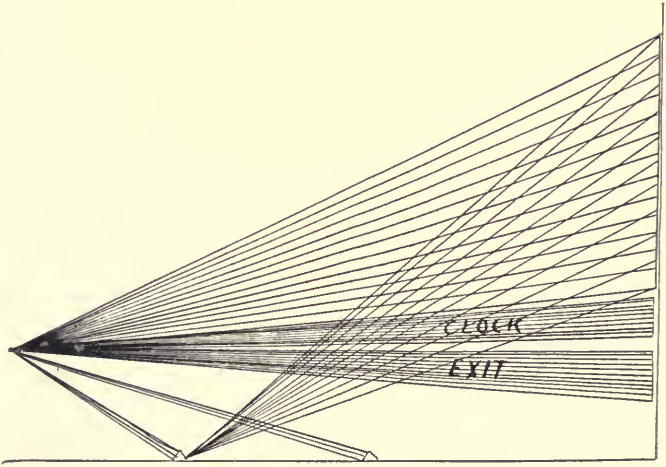


Figure 67½.

In their pamphlet, "The Motion Picture Theatre, Its Illumination and the Selection of a Screen" (which we commend to the projectionist for addition to his library), the Eastman Kodak Company says:

"No area of the interior of the theatre visible from any seat in the audience, except the picture itself, should have an apparent brightness of more than 2.5 to 3.0 foot-candles. This applies to the walls near a lamp, to the lamp itself if it is not concealed, to any diffusing globes or fixtures used, and in general to any part of the interior of the theatre. For example, a sheet of white paper illuminated by a 25 watt lamp at at distance of one foot, has an apparent brightness of about 20 foot-candles. A sheet of music illuminated in this way, if visible from the audience, becomes a glare spot and may cause great discomfort. Arrangements should therefore be made which, while providing adequate illumination for the musicians, will prevent the illuminated sheets from being visible to the audience. Lights under a balcony are particularly bad and should be used only with a properly designed indirect lighting system. Considerable attention should be paid to the character and position of exit signs. While it is necessary to make such signs very conspicuous, this can be accomplished without making them so brilliant as to become disagreeable glare spots."

We agree with every word of the foregoing. Glare spots caused by side lights, clocks, wrongly-made exit signs, lights on the ceilings of balconies, and music lights, are nothing else than a crime against the eyesight of this and future generations. They are the product of carelessness or ignorance, or both. They have no legitimate excuse under heaven.

In Fig. 67½, A is the eye of a spectator looking at a screen, with four more or less concentrated points of light glaring into his eyes, viz.: two "side lights," a clock light and an exit sign located beside the screen and unintelligently illuminated.

If it is desired that a clock be located on the theatre front wall its face may be illuminated acceptably, and absolutely without glare, as follows:

From a photographer secure a sheet of dull black paper, such as comes wrapped around photographic plates. Cut it circular and the size of the clock face. Have a painter paint numerals (Roman) from one to twelve, in their proper place. Cut a half-inch-diameter hole in the center for the clock hand post. Split the paper from outside to center hole between any two figures, which enables you to slip the black face under the clock hands without disturbing them, whereupon it may be attached to the clock face, with numerals in correct position, by means of a few spots of Le Page's glue, without in any way injuring the white clock face, because upon removal of the black face the glue may be moistened and washed off.

Now paint the hands dead white, or affix to them false hands made of lightweight white cardboard, which may be done by means of a white thread. Make the paper hands considerably wider than the original hands.

Now suspend an incandescent lamp in a can, or suitable box, and in one side cut a hole just barely large enough to let out a circle of light of sufficient diameter to illuminate the clock face, AND NOTHING ELSE. Or, better still, affix in a hole in the side a small lens which will project a circle of light covering the clock face AND NOTHING ELSE.

The audience can read the time from white hands on a black face very much more readily than from black hands and a white face, and your glare spot will have been entirely eliminated.

EXIT LIGHTS can be made conspicuous, and at the same time absolutely non-glaring, as follows: Paint the letters EXIT in red letters of suitable height, and outline them in black, so that only the letters show—which is exactly what is wanted. No official with a grain of sense or an atom of knowledge concerning theatre lighting can or will object to this, provided you do it intelligently. The capable official will commend the plan.

You may make your present black-letter-on-light-red-ground glaring exit signs both efficient and harmless by shoving in a sheet of DARK RED glass between the light and the letters, or two sheets of light red glass if the dark red cannot be had. It will cost you a few cents, yes, but will add immeasurably to the comfort of the eyes of your audiences.

CAUTION.—Don't imagine that because no one complains, your glare spots are unobjectionable. The theatre patron does not blame the right thing when his or her eyes hurt. He does not know or realize the seat of the trouble, and blames it on "the pictures." But the point is that he or she stays away from picture theatres because "the pictures hurt my eyes," or else go to another theatre where "the pictures don't hurt my eyes" because the man there is on to his job and does not tolerate glare spots.

WARNING.—Do NOT use an exit sign with black letters on a glass painted red. The paint may be O. K. at first but soon begins to scale off, and a glare spot is thus gradually set up before you realize it. USE RED GLASS ONLY. It may be had of or obtained for you by any dealer in photographic supplies.

FLAT SURFACES—LOCATION.—Whatever the surface of the screen be composed of, it is plain that it should be as nearly as possible perfectly flat, without wrinkles, bumps or uneven places, and that its color and "brilliancy" should be precisely the same for every portion of its surface. The screen should always set as nearly as possible with its center level with, and in line sidewise with the projector lens. This latter condition is practically never possible of accomplishment where two projectors are used, since one or the other or both must necessarily set slightly to one side of the center of the screen.

OUTLINING THE PICTURE.—No matter what type of screen is used, the picture should invariably be outlined in some very dark non-gloss color. This outline should be at least 2 feet wide, top, bottom and sides, and 3 or 4 feet is better. The outline should extend slightly into the picture. In other words the picture should overlap slightly on the outline, say one or 2 inches all around.

The reason for this latter recommendation is that it serves to greatly minimize the effect of any movement of the pic-

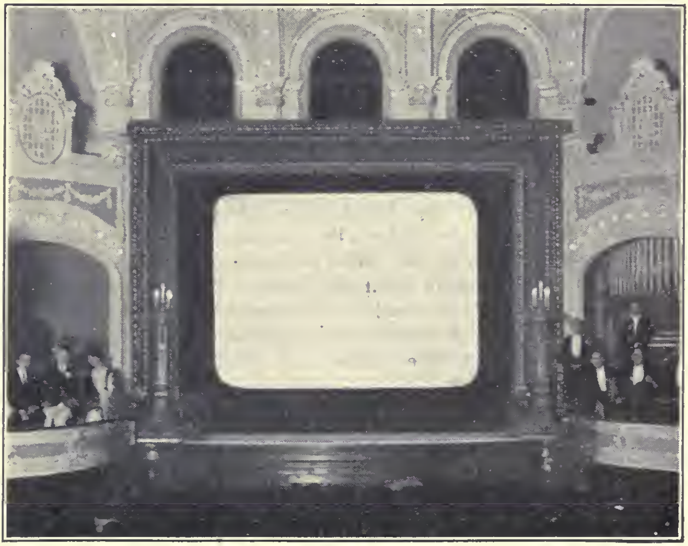


Figure 68.

ture as a whole on the screen; also it serves to conceal any vibration there may be in the projector aperture itself.

The effect of the outline is to secure added contrast for the picture. A picture projected to the center of a white screen without an outline has not anything like the sharp, pleasing contrast which the same picture has when projected to a white screen properly outlined by a dark border, or a border of dead (non-gloss) black.

In Fig. 68 we see a characteristic moving picture theatre screen setting, with the screen outlined in black. In former books we have invariably recommended non-gloss black for the picture outline, but while this is ideal in some ways, it frequently happens that black will not harmonize with the other screen surroundings. In view of this fact, this particular recommendation is modified to the extent that any reasonably dark non-gloss color will serve fairly well as a picture outline.

The Eastman Kodak Company laboratories have made certain rather exhaustive experiments, seeking to determine the best methods to pursue in the matter of screen surroundings and picture outline border. Concerning the latter they say:

"Some observations were made during the course of the experiments which will probably upset some existing conventions and increased the comfort of the motion picture patrons. For instance, the black velvet frame which frequently surrounds the screen is found undesirable and a neutral gray is suggested in its place. The reason is simple. Suppose the illumination of the strongest highlight of the picture is 10 foot candles. Under these conditions the brightness of the black velvet frame would be found to be about 0.001 foot-candles. This makes the ratio of the two or the brightness contrast equal to 1 to 10,000. This contrast is beyond the power of the eye to record and results again in overtaxing the process of adaptation. By using a material with a higher reflecting power than black velvet, the contrast between the screen and the frame may be brought within the range of the eye. If the brightness of the frame is raised to 0.02 foot-candles, the contrast between the strongest highlight in the picture and the frame is 1 to 500. Scientists say that this is about the limit of contrast which the eye can endure with comfort. In general, therefore, the black velvet frame should not be used but, in its place, a material which has a reflecting power sufficient to raise the apparent brightness of the frame to something like 0.02 foot-candles.

"The selection of the material will depend upon a number of factors: the illumination of the theatre and the distance of the screen behind the front of the stage being the principal ones. For experimental purposes in the laboratory it was found that covering the black frame with white mill net was quite satisfactory. Such an expedient will not in general be found satisfactory in practice since this material will undoubtedly fail to harmonize with the elegance and richness of finish frequently found in the modern motion picture theatre. In many cases the screen area is surrounded by drapings of silk, velvet, or other fabrics and in such cases it is suggested that a fabric harmonizing with the general decorative scheme be used as a draping immediately around the screen area, the color that will give a satisfactory result being such as in ordinary terminology is referred to as a rather dark gray. A very pleasing result was obtained in an experimental installation by the use of a screen frame covered with a warm-gray burlap such as is used for wall coverings. In case the decorative scheme is carried out not by the use of fabrics but by the use of painted surfaces, the frame should be made by use of a rather dark gray paint. Of course, it should be understood that in case a true gray does not harmonize well with the decorative scheme of the interior some rather dark color tone (including colors usually referred to as warm or cool grays) may be used with advantage. In any event, small samples of fabric or small panels painted with various colors should be tried by placing them temporarily in position near the screen and the final choice made when a material or paint is found having a reflecting power such as to make the frame appear of the correct brightness."

We are unable to altogether agree with this. We see no reason why the screen border should be visible to the eye at all. In fact, the less visible it is, it seems to us the better is the condition. However, we yield all due respect to the views of the gentlemen who made these experiments and pass the matter along to you for consideration, with the note that we still adhere to our recommendation of either a dead black, or at least a very dark non-gloss screen border.

We commend the booklet issued by the Eastman Kodak Company, entitled "The Motion Picture Theatre, Its Illumination and the Selection of the Screen."

It is a twenty-four-page, paper-covered phamplet. It will be sent gratis to projectionists who say in what theatre they are employed. Get it for your library.

NON-GLOSS SCREEN SURROUNDINGS.—As to the immediate screen surroundings, it is highly important that they be absolutely non-gloss in character, and not too light in color. This is of very great importance indeed where an orchestra of considerable size is located immediately in front of, or near the screen. Very great injury is often done to the screen result by the light reflected by the white sheet music to the light colored semi-gloss screen surroundings, and by them re-reflected back to the screen. Where there are from 20 to 40 orchestra lights it requires no great wisdom to understand that a vast amount of reflected light may reach the screen in this way, all of which not only adds extraneous light to the lighted portions of the picture, but also **to the shaded and black portions,** causing the latter to appear a dirty gray color, instead of pure black. The direct effect of this is to very greatly injure the contrast of the picture.

PAINT STAGE FLOOR.—Where a screen is set well back on the stage of a theatre having a balcony, it is highly important that the floor of the stage be either covered with non-gloss black cloth or painted non-gloss black. Unless this is done the light reflected from the floor will be very annoying to the eyes of the patrons seated in the balcony or at least it will detract from the contrast and beauty of the picture.

SIZE OF PICTURE.—(Also see "Definition and Magnification," Page 245.)—The size of the picture has been the subject of perhaps more argument than any other one thing in connection with the motion picture theatre auditorium. This is because of the fact that a number of things are directly involved in the matter. The author of this work has always opposed large pictures. He has repeatedly said, and does still say, he has never yet seen a theatre in which he considered there was any real necessity for a picture of greater width than 18 feet, and those theatres which really require a picture wider than 16 feet are very rare indeed.

The author has stood in Madison Square Garden, New York City, at a distance of more than 200 feet from a 16-foot picture and has been able to read both the titles and subtitles with very little effort. He was able to follow all the action of the photoplay without the slightest difficulty.

Mażda projection has served to demonstrate the fact that what was formerly believed to be an impossibly small picture is really plenty large enough for the ordinary theatre. We have watched the projection of a 12-foot picture in a theatre seating 1,500, with the audience apparently thoroughly satisfied.

We will now endeavor to discuss this matter of picture size in some of its more important details. In the first place the size of the picture has directly to do with the value of the front rows of seats, because if the picture be too large in proportion to its distance from the front row of seats, then those occupying the front seats will be subject to heavy eye strain, besides having a highly unsatisfactory view of the picture. The value of these seats will therefore be greatly reduced. The eye strain will be caused by two separate things, viz.: first, the picture will not appear in sharp focus, which in itself causes heavy eye strain; second, if the person be seated too close to a picture of large size the movement of the eye in following the action on the screen through the wide angle involved will set up terrific strain.

After a great deal of study, observation and consideration we have concluded that the front row of seats should never be closer than 20 feet from a 16-foot picture, and in order that the same angle of view be maintained it is necessary that one foot 3 inches of additional distance be added for each additional foot of picture width.

In exact opposition to the foregoing it must be remembered that if the picture be too small and the auditorium be a long one, then eye strain may be set up for those who occupy the rear seats, though this ordinarily only holds good where the rear seats are an unusually great distance from the screen.

We think we may safely say that there will be no appreciable eye strain for those of normal eyesight if no seats be a greater distance than 100 feet from a 16-foot picture. As a matter of fact a great many people would experience no eye strain at a considerably greater distance, but we believe 100 feet may be accepted as a fairly safe guide for the average eye. Those who experience eye strain at that distance can of course secure seats nearer the screen and we must remember that the smaller the picture the more brilliant it can be made, hence the greater distance it may be viewed without eyestrain.

The smaller the picture, within reasonable limits of course, the more valuable the front rows of seats become.

Except under very unusual circumstances we strongly recommend that no picture exceed a maximum width of 18 feet. As to the minimum, it may be fairly said that a 10-foot-

wide picture is about as small as any one would care to use for theatrical purposes.

DEFINITION AND MAGNIFICATION.—Increase in picture size is only had by increasing the magnification of the film photograph in its image at the screen, with the natural result that definition is impared, it very seldom being perfectly sharp in the photograph itself to begin with. See magnification of defects, page 246.

PICTURE SIZE AND LIGHT DEMAND.—It must be remembered that as the size of the picture is increased the amount of light necessary to maintain its brilliancy per unit of area increases rapidly.

The magnification of the film photograph is in any event enormous. Its linear magnification may be found by multiplying the width of the image in inches by 32 and dividing that result by 29. The result will be the number of times the film photograph is magnified in the width of the screen image, the projector aperture being 29/32 of an inch wide. The following figures are interesting.

Table No. 9.

Size of Picture.	Surface Area.	Magnification.
9x12	108 Square feet	158.88 diameters
12x16	192 Square feet	211.84 diameters
15x20	300 Square feet	264.80 diameters

If you were to cover a 16-foot picture with film photographs just the size of the projector aperture it would require 44,944 of them to do it. And since there are 16 photographs to the foot of film it would be necessary that 2,788 feet of film be cut up to supply the photographs.

Table number ten gives the height and area in square feet of pictures from 10 to 20 feet wide, by one foot steps. It also gives the percentage of illumination or brilliancy per unit of area each size would have as compared with the 10-foot-wide picture, amount of light passing the revolving shutter of the projector being the same in all cases.

Table No. 10 is enlightening. We find that by increasing picture size from 10 feet to 14 feet we have decreased its brilliancy by 49 per cent., and that a 16-foot picture will require 61 per cent. additional light to be as brilliant as the 10-footer.

Of course the table assumes that the same percentage of the total light reaches the screen in every case. For practical purposes the percentage column really shows the percentage of area in reverse. For instance: the 10-foot picture has just 25 per cent. of the area of the 20-footer; the 10-foot picture has just 39 per cent. of the area of the 16-footer, and so on.

Table No. 10.

Width in Feet.		Height in Feet.	Area Sq. Ft.	Brilliancy.
7.50	x	10	75.	100 per cent.
8.25	x	11	90.75	82 "
9.	x	12	108.00	69 "
9.75	x	13	126.75	59 "
10.50	x	14	147.	51 "
11.25	x	15	168.	44 "
12.	x	16	192.	39 "
12.75	x	17	216.75	34 "
13.50	x	18	243.	29 "
14.25	x	19	270.75	27 "
15.	x	20	300.	25 "

MAGNIFICATION OF DEFECTS.—One phase of picture magnification, or picture size, should not be overlooked, especially by the exhibitor showing old films, viz.: the effect of magnification on defects. As has been shown, the magnification of the original photograph in any picture of theatrical size is terrific. But in the larger sizes it is, of course, very much greater than in the smaller.

Applied to defects, suppose you have film which has a good deal of "rain." If the actual scratch in the film itself be .015625 (1/64) of an inch wide it will appear as a mark approximately 2.5 inches wide in a 12-foot picture, but in a 20-footer it will be widened to a little more than 4 inches. We thus see that as the picture width is increased all defects in the film photograph are magnified and made more visible, but especially this applies to rain, it being more or less continuous throughout old film.

It may also be noted, in passing, that any side motion of the film in the aperture will be magnified on the screen in the same proportion. If the film moves sidewise .015625 (1/64) of an inch in the aperture, the 12-foot picture on the screen moves about 2.5 inches and the 20-footer moves a little more than 4 inches.

TINTED SCREEN SURFACE.—Many experiments have been made with intent to soften or improve light tone by means of tinting the screen surface. We have never been enthusiastic about the scheme. We believe that the glaring whiteness of the light from a high amperage arc may well be softened, but this should be done either by chemicalization of the carbons or by the employment of lenses made of glass which will accomplish the purpose.

That the former is possible has apparently been amply proven by the work accomplished in the controlling of the tone of the light emanating from alternating current carbons by means of chemicalization of the carbons themselves. That the latter is possible, without serious light loss, has been proven by the "amberlux" lens which was for a considerable period of time marketed by H. Dashler Warner, of Columbus, Ohio. This latter was nothing more than a plano surface glass, which slipped into the jacket of the projection lens at the screen end of same. It had the effect of mellowing the light tone by removing the chalky glare, and seemed to do it without serious loss of screen brilliancy.

To sum up, we are firmly convinced that the screen surface should, except in very narrow auditoriums, be as nearly as possible a perfect diffusing surface, that it should present a perfectly flat surface, and that the surface should be as white as it is possible to get it, the possible resultant chalkiness of the whites being eliminated by one of the means suggested.

LOCATING THE SCREEN AT THE FRONT OF THE HOUSE.—Experience has amply proven that the location of the screen at the end of the auditorium where the audience enters, with the projection room at the opposite, or rear end of the auditorium, is very bad practice indeed. Its effect is not good in any way, and when we consider the fact that the modern projection room is absolutely fireproof, and that if the port shutters be properly constructed and fused, and the projection room be properly ventilated, no evidence of any fire which may occur therein will be visible in the auditorium, we readily see that absolutely no element of safety is served by a front of the house screen location. Local authorities will do well to pay more attention to the proper construction of the projection room, the proper construction of its port fire shutters, the proper location of the fuses controlling the port fire shutters, and the proper ventilation of the projection room, instead of evolving such utterly useless, not to say foolish schemes as placing the screen at the entrance end of the auditorium.

LOCATION OF SCREEN ON STAGE.—Where the screen is located on a stage, and the theatre is used for motion pictures only, the screen should in any event be located far enough back so that there will be a minimum distance of 20 feet between the front row of seats and the screen, if the picture be 16 feet or less in width. See Page 244. **For each added foot of picture width there should be an additional one foot and three inches between the front row of seats and the screen in order to maintain the same viewing angle from the front seats.**

If the depth of the house from the proscenium to the rear row of seats be not to exceed 75 feet, it is always very much better to set the screen back on the stage as far as it can be placed without interfering with the view of the screen from the extreme front side seats. Those in the rear seats will still be close enough to have a good view of the screen, while those in the front rows and at the side of the auditorium will have a vastly improved view over what it would be if the screen were further front.

COMBINED VAUDEVILLE AND PICTURES.—Many theatres use a mixed performance of vaudeville and feature pictures. Where this is done it is very much better that the pictures follow the vaudeville, because the screen may then be placed at the rear of the stage, where those occupying the front rows of seats will have at least a fairly good view without serious eye strain. If the pictures precede the vaudeville, then it will usually be necessary to place the screen near the front curtain, in what is known in theatrical parlance as "one," in order that the stage may be set for the first vaudeville act while the picture is running. This sets up a very bad condition for patrons occupying the front rows of seats. They will experience heavy eye strain by reason of the fact that the picture will not appear to them in sharp focus, and for other reasons set forth on page 244.

In theatres using a combined vaudeville-picture bill there is, except in a comparatively few isolated cases, an astounding indifference shown to the proper presentation of the picture, although the picture in many cases supplies fully half the bill. The screen more often than not is badly located, and very often is to all intents and purposes merely a flat sheet of very poorly coated muslin.

In such houses the screen should be stretched on a substantial frame, and should slide up and down in grooves. The screen should be properly counter-weighted, as can be very easily done in modern theatres. Where this plan is used the screen will always be precisely in the same place, and currents of air will not move its surface.

We have often sat in a high-class vaudeville-picture theatre charging top hole prices, and have watched a scene perhaps containing huge buildings sway backward and forward, because the management had failed to properly support the screen by a framework, but were using a painted drop weighted at the bottom by a wooden strip, with result that every time there was an extra strong current of air the screen moved to and fro.

TRAVELING EXHIBITORS may carry a painted cloth screen or metallized surface screen successfully, always provided it be rolled face inward on a round wooden rod not less than 3 or 4 inches in diameter, and further provided that a clean muslin sheet be spread over the surface of the screen before it is rolled, this in order to protect the surface from dirt which may accummulate on the back of the screen. A painted screen rolled on such a support (which latter may be made up by nailing thin wooden strips, such as lattice work is made of, around round wooden end and center supports) will not be very bulky and its surface will not crack. Of course if the screen is to be shipped by express, then an outer wooden covering would necessarily have to be made for it.

CAUTION.—The screen should be rolled as tightly as possible in order to prevent the surfaces rubbing against each other in transit.

FIREPROOFING SOLUTION.—Any screen or other fabric may be fireproofed by thoroughly saturating it with ammonia phosphate, mixed in the proportion of one pound to one gallon of water. In applying the solution to a cotton screen it should first be tightly stretched on a frame and the solution applied with a cheap paint brush, prior to the application of the glue sizing. Let the fireproofing dry thoroughly before applying the glue size.

Fabric which has been thoroughly saturated with ammonia phosphate solution will char, but it will not and cannot be made to blaze. If you hold a lighted match against the fabric the result will be a hole charred in the cloth—that is all. There is nothing in ammonia phosphate that will in any way injure the fabric. Wood thoroughly soaked in the solution is made fireproof in the sense that it cannot be made to blaze.

STRETCHING THE SCREEN.—The wide use of metallic surface screens, many of which are constructed of heavy cloth or canvas, makes it very difficult to stretch them tightly, though tight-stretching is necessary since with a semi-reflective surface every wrinkle or uneven place will show badly.

There is nothing better for this purpose than what is known as the "artist frame." It is very much superior to any home-made arrangement. and may be purchased from almost any screen manufacturer for less than it would cost an exhibitor to make it. It is simple, and we believe quite satisfactory. It may be shipped knocked down, and the process of putting it together is one which can be readily performed by any man of ordinary intelligence.

Figure 69

Begin to put the frame together by laying it bottomside up, on a floor, or other flat surface. After the corners are bolted together see that the whole frame is exactly square. This may be tested by measuring diagonal corners. If the distance from diagonally opposite corners is equal the screen, as a whole, is square. Next, put on the back braces and then turn the frame over, or set upright in place. The various steps in the process are shown, in their order, in Fig. 71.

Figure 70

PUTTING ON CLOTH. — The cloth should be rolled up so that the edge that goes to the top unrolls first. It may be put on either with the frame standing up or lying down. Standing the frame upright is the best plan, however, because the cloth will partly stretch by its own weight, and the whole job will be more easily and better done. A good start is a long step toward success. Lay the roll of cloth on a level floor, unroll a foot or two, and stretch a chalk line to determine whether or not its edge is perfectly straight. Trim it if necessary to fit the chalk line. Now make a chalk line across near the extreme edge of the top of the frame, on the front side, where the cloth is to be tacked. The straight top edge of the cloth and the line on frame are placed together and the cloth is tacked fast, thus insuring a good, straight start.

TACKING ON CLOTH.—Place the tacks about two inches apart. A thin tack with a large, flat head is the best. If the frame is placed upright a piece of cheese cloth should be looped and nailed to the frame on each end, to hold the roll of cloth in position while the top edge is tacked in place. Start at the center of the top, and tack both ways along the chalk line, until within about three or four feet of the corner. A single tack will hold each corner in position until you are ready to tack corners. Now unroll cloth slowly and carefully, keeping it stretched at all times. Stretch and tack the bottom of screen, beginning at center and working again to within three or four feet of each corner. Next tack one side from center to within a short distance of corner, and then tack and **stretch** the cloth on the other side, after which finish up the corners.

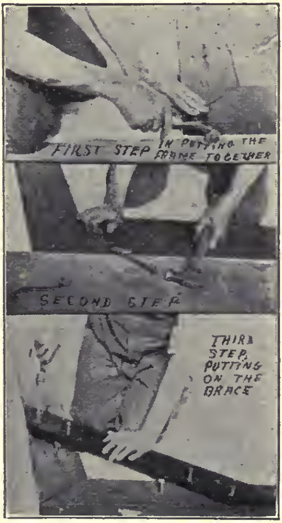


Figure 71

In tacking any cloth screen always begin at centers of top, bottom and each side, and finish corners last.

If the work is done carefully the surfaces will be almost entirely free from wrinkles, and where a light cloth is used and well stretched by hand a very even surface is possible on a common hand-made frame. The artist frame we are describing is provided with finishing strips which are added in order to cover up the tacks and raw edge of the cloth, which helps the appearance very much. Beveled **stretcher** strips are then pushed down between the cloth and frame from the back, giving the appearance of a bevel around the edge on the face side. This gives a handsome, finished appearance to the screen generally.

In most cases the cloth is free from wrinkles when the stretcher strips are put in position, but to provide for further stretching lag bolts are placed in the frame which, when screwed in, push out the stretcher strips still farther, so that the screen can be made as tight as a drumhead. The artist frame is always good property, as it can be used again for new cloth. Those exhibitors who use metallized screens should renew them at least every two years. Many metallic screen surfaces lose their brilliancy in even less time, and often those of inferior quality will become dull within a few months. Fig. 69 shows front of finished screen.

SIDE VIEW DISTORTION.—The effect of viewing the screen at heavy angle should be, but apparently is not, thoroughly understood by architects. To a person seated at an extreme side angle to the screen all figures thereon appear to be abnormally tall and very thin. The explanation for this is very simple.

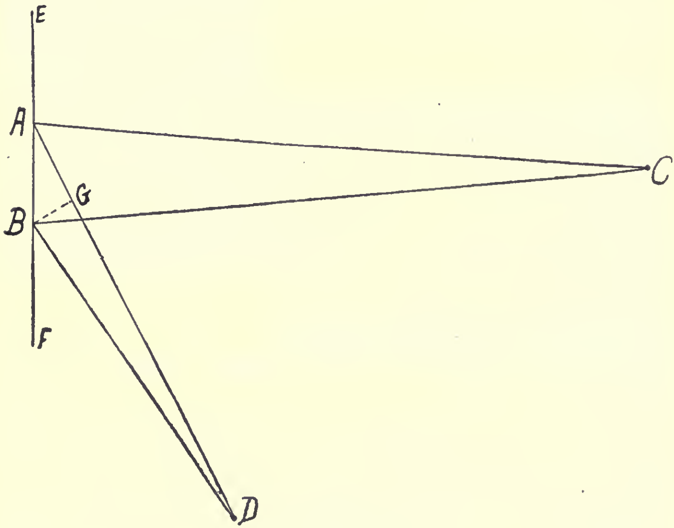


Figure 72.

In Fig. 72 we view a theatre screen E F, A B an object in the picture on the screen, and C and D the eyes of two spectators, one seated directly in front of and the other at a wide angle to the surface of the screen. C of course sees object A B at its full width, but, remembering that the object on the screen is only an image, hence absolutely level or flat, it is evident that D will get the effect only of width B G. This explains the apparent lack of breadth in the object. The effect of abnormal tallness is, however, partly due to the foreshortening of the width of the object. We have been accustomed to seeing a man or woman of a given height have, within certain limitations, a certain given breadth. If we foreshorten the breadth unnaturally the effect is to give the impression of greatly added height.

Another reason for the apparent tallness is that it is reality. The figures on a screen are often very much taller than in real life. This is not realized because they have the customary proportions. If, however, the breadth be foreshortened until a figure ten feet tall has only the width of a normal man or woman the effect is a ridiculously tall, thin caricature of the original.

The lesson taught by this is that patrons should not be seated at too wide an angle to the screen. Architects may readily determine exactly what the effect in foreshortening of width will be at any given angle by applying the simple process shown in Fig. 72.

DISTORTION — KEYSTONE EFFECT. — The distortion of the picture and its outline caused by the projection lens being out of center with the screen is commonly termed "keystone effect," because of the fact that when the projection lens is considerably above the center of the screen (the condition most commonly met with) the picture outline assumes, in greater or less degree, according to the condition, the shape of an inverted keystone.

This is illustrated in Fig. 73, in which A is the projection lens, B C the screen, E F a horizontal line perpendicular (at right angles) to the surface of the screen at its center, B D the position screen B C must assume in order that its surface be perpendicular to (at right angles with) the axis of projection, D C the distance lower margin of the light beam must travel in order to reach the screen surface in excess of distance travelled by the upper margin. The solid lines of H show the resultant shape of picture on the screen, and the broken lines what the picture should be and would be were lens A located at E, or screen B C in position B D. Observe that the picture will be wider at the bottom and narrower at the top than it would be were the axis of projection along line E F—the projection lens central with the center of the screen. Analyzing Fig. 73 we find approximately as follows: Distance of projection being 80 feet and the width of the picture 16 feet at its center, it would, under normal conditions be twelve feet high. Since the picture is 192 inches (16 feet) wide, the beam must spread out 192 inches divided by 80 feet equals 2.4 inches for every foot of projection distance. Distance D C is 3 feet 8 inches, or 3.66 feet, hence with the screen in perpendicular position the

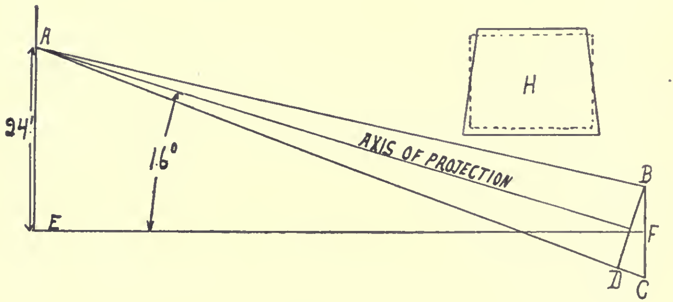


Figure 73.

beam must travel 3.66 feet further in order to reach the lower edge of the screen than to reach its top. It therefore follows that the beam will be 3.66x2.4 inches=8.786 inches wider at its bottom than at its top, and proportionally all the way up and down the picture, thus producing the shape known as "keystone," shown by solid lines at H, Fig. 73.

Fig. 74 gives us the number of inches drop in projection per foot of distance when the angle is 12 degrees. It is 2.55 inches. If it is proposed to have the lens a certain height above screen center, and a given distance from the screen (distance of projection) it is only necessary to multiply the projection distance, in feet, by 2.55 to know whether the angle will be more or less than 12 degrees. If the result is greater than the proposed height of the lens above screen center, **measured in inches,** the angle is less than 12 degrees.

For instance: Proposed projection distance 60 feet. Proposed height of lens above screen center ten feet (120 inches). 2.55x60=153, hence at 60 feet the lens must be 153 inches above screen center to produce a 12 degree pitch. Its proposed location is less than that, hence the angle will be less.

PROJECTION ANGLE NOT SAFE GUIDE.—The Society of Motion Picture Engineers has set 12 degrees from a horizontal line passing through the center of the screen (it is not so stated, but presumably that is what is meant) as the maximum permissible angle of projection. This, as is shown in Fig. 74, means a horizontal rise of 2.55 inches each foot of projection distance.

Let us examine the matter. Assuming a 96-foot projection distance, a 12-degree angle and a 16-foot picture, we

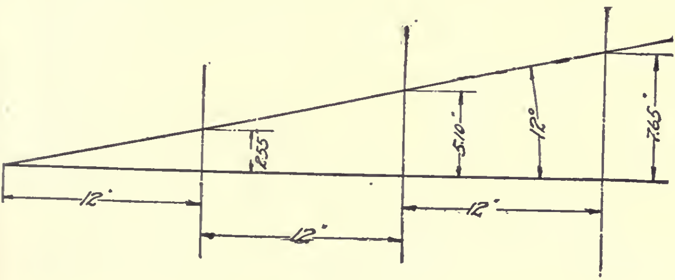


Figure 74.

find that the beam will spread just 2 inches per foot. Using a similar angle and the same size picture, but a 50-foot projection distance, we find the spread of the beam to be 3.8 inches per foot, but since both the angle and picture size remain constant, distance D C, Fig. 73, will remain unaltered, and since the spread per foot of the beam is greatly altered by the changed distance of projection, the resultant distortion of the picture will be very much greater on the short projection distance than on the long. Hence we say that angle of projection is not always a safe guide.

In our opinion the only reliable guide to permissible projection angle is the amount of distortion a given condition will produce, and up to this time no competent authority has undertaken to say what amount of distortion may be tolerated. It must be remembered that the resultant distortion is present all over the image. It is not confined to the picture outline, but alters the relative width of things in different portions of the picture, as well as making the whole picture and everything in it abnormally tall. In fact this latter is the worst feature of the distortion. Outline distortion may be corrected by filing the aperture plate opening. Distortion of width of objects in the picture usually is not very noticeable, but added height is very readily discernible.

Fig. 75 illustrates the effect of projection distance on projection angle, height of projection lens above screen remaining the same. If the lens be located 25 feet above screen center, and the projection distance 40 feet, the projection angle will be 32 degrees. With the projection distance 80 and 120 feet respectively, the projection angle is

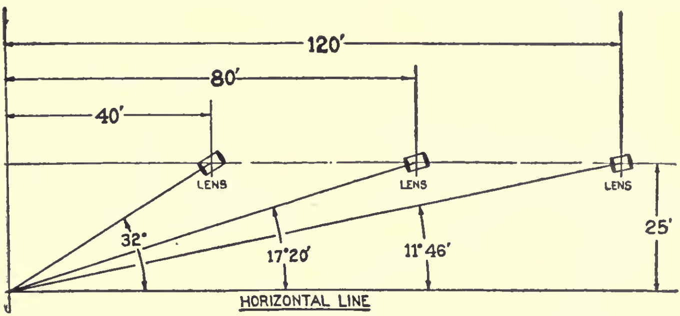


Figure 75

reduced to 17 degrees and 20 minutes, and 11 degrees and 46 minutes.

It is the opinion of the author that picture height offers the best and safest guide to permissible projection angle, and **that any projection room location which increases the normal height of the picture by more than 5 per cent. is objectionable and should not be tolerated.**

It will be observed that this permits an increase of the height of a sixteen-foot-wide picture by a trifle more than seven inches, so that at 80 feet projection distance a 15-degree angle would be within the limit by .2 of an inch. This would automatically add a maximum of 5 per cent. to the height of all objects on the screen, including the actors, so that a six-foot man who happened to appear just life size in a normal size picture would appear as being 6 feet, 3.6 inches tall; also his head would be smaller in proportion than his feet, though this latter, if confined within this range, will not injure the results perceptibly.

While the following figures are not exactly correct, they are nearly enough so for our purpose.

Given a projection distance of 80 feet, the following projection angles will increase the height of a 16-foot-wide picture as follows:

Angle of 10 degrees increases height 4.5 inches.
Angle of 15 degrees increases height 7 inches.
Angle of 20 degrees increases height 13 inches.
Angle of 25 degrees increases height 20 inches.
Angle of 30 degrees increases height 32 inches.

WHEREIN THE EVIL OF DISTORTION LIES.—The average exhibitor, and very many unthinking projectionists, believe that so long as the sloping sides of a distorted picture are made perpendicular, which may be done (see Filing the Aperture below), there is no remaining evil except the added difficulty of obtaining sharp focus all over the screen. They base their belief on the fact that the theatre patrons do not know or realize that the picture is distorted, hence no harm is done.

This is fallacious reasoning. Admitting the fact that if the sides of the distorted picture be made perpendicular, the audience, having nothing as a basis for comparison, probably will not know the distortion is present, the fact remains that **the distorted picture is not nearly so pleasing to the eye as the undistorted one, or the one only slightly distorted, and since theatre patrons pay admissions to theatres in order that they may be amused and entertained, it follows that the more pleasing the appearance of the picture as a whole, aside from its merits as a play, the better satisfied the patron will be, and the better satisfied the patron is, the more he is likely to patronize the box office frequently.**

FILING THE APERTURE.—Side lines of Keystone may be made parallel by filling side of aperture with hard solder or procuring special aperture plate from projector manufacturer and filing sides to suit. First project light to screen and make mark on screen at lower ends of top corner curves. Then remove aperture and fill in sides or substitute special aperture. Next place a metal plate over the lamphouse cone, in the center of which is a hole about ⅜ of an inch in diameter. Next hang cords at the screen so that they will pass down exactly over the marks you have made at the bottom of the upper corner curves. Now strike an arc, and, with the light through the hole in the plate over the cone to guide you and show you the exact effect of every move, file out the aperture sides until the light comes exactly to the lines on the screen.

The light enables the worker to watch the exact effect of every stroke of the file. He is thus enabled to do a very accurate job. It is necessary to be extremely careful in filing because if you get a bit too much metal off at any stroke of the file it means the job must all be done over again.

Keystone effect is invariably accompanied by a greater or less tendency to out of focus. This is especially true if it be side keystone, since the picture is wider than it is high. It is caused by the fact that a projection lens is presumed to focus at a given distance, (Fig. 36 D), and since with distortion of the kind we have described the distance to the screen varies, it will readily be seen that a strain is placed on the powers of the projection lens in the matter of focusing. The lens may be given increased depth of focus, or in other words may be caused to focus over a greater distance by reducing its diameter, and this is why large diameter objectives are a very hard proposition to handle where there is any decided tendency to distortion in the way of keystone effect. If the projectionist is working under conditions of heavy distortion or keystone and is unable to get a sharp focus all over his picture, let him try stopping down the diameter of his projection lens by inserting a ring of black cardboard in the front end of the lens barrel, right up against the front factor of the projection lens. In the center of this cardboard cut out a circle say one inch in diameter. If this sharpens the picture, then he can know where the trouble lies and can increase the size of the hole in the stop until the trouble again appears, after which a new metal disc with an opening just a little bit smaller will serve the purpose. We know of no other means of remedying such a condition, so long as the distortion remains, and the remedy we have suggested may be quite expensive in light, therefore it is a waste of electric current.

CHARACTERISTICS OF SCREEN SURFACES.—The following data is extracted from a paper presented to the Society of Motion Picture Engineers by Lloyd A. Jones and

Milton F. Fillius, contained in the Dayton transactions of the society. The data contained is the result of three complete sets of readings made by two different men, of each surface tested, so that apparently the liability of error is very small indeed. It is greatly to be regretted that kalsomine and paint surfaces were not tested, but the data nevertheless marks a very distinct step forward, since it provides the exhibitor and projectionist with a basis for intelligent comparison, as well as data which should enable him to select a screen surface suitable for use in the individual theatre by some other method than guess work, statements of salesmen or personal observation, none of which methods have very much value.

In making the comparisons a magnesium carbonate surface was selected as a basis, and its power of reflection was given an arbitrary value of 100 per cent. The reflection value of all other surfaces is therefore given as the percentage of reflection power of the magnesium carbonate surface.

In Table I is given a complete list of the materials measured.

The surface of the magnesium carbonate sample (1) was prepared by carefully scraping a block of the material with a steel straight-edge. The opal glass (2) was of the best quality obtainable for uniformity and whiteness, and the surface was carefully ground. The white blotting paper (3) was of the ordinary commercial quality used extensively in photographic work. The photographic stock (4) was a sample of uncalendered and uncoated material. No. 5 was of the same material but treated with the ordinary baryta coating. The drawing paper (6) was the commercial grade of Wattman's hot pressed. Sample No. 7 was prepared by sandblasting a sheet of aluminum. No. 8 was made by sandblasting the front surface of an ordinary plate glass mirror. No. 9 consists of a screen made by superimposing a sample of the material such as is commonly used as the focusing screen in photographic apparatus upon the surface of an ordinary plate glass mirror.

The commercial screens examined and tested also are listed in Table II, beginning with No. 10. In the name column of Table II will be found the trade name applied to the surface by its manufacturer, in the texture column a qualitative statement of the character of the surface, and in the color column a qualitative statement of the color of the surface. Let it be understood, however, that the terms used in describing texture and color are very general in their nature, as no precise qualitative measurements were made of these characteristics.

CLASSIFICATION OF SURFACES.—An examination of the characteristics of the screens examined and tested show they may be roughly grouped into three general classes, A,

TABLE 12

No.	Class	Name	Texture	Color
1	C	Magnesium Carbonate	Smooth	White
2	C	Opal Glass	Smooth	White
3	C	White Blotting Paper	Smooth	White
4	C	Photo Stock Plain	Smooth	White
5	C	Photo Stock Coated	Smooth	White
6	C	White Drawing Paper	Smooth	White
7	B	Sandblasted Aluminum	Smooth	Metallic White
8	A	Sandblasted Mirror	Smooth	White
9	A	Focus Screen and Mirror	Smooth	White
10	A	Superlite	Coarse Grain	Metallic White
11	A	Special	Coarse Grain	Metallic White
12	B	Green Back	Fine Grain	Metallic White
13	B	White Back	Fine Grain	Metallic White
14	C	Plain White Coated	Smooth	Yellow
15	A	Imsco Silver No. 1	Coarse Grain	Metallic White
16	A	Imsco Gold No. 1	Coarse Grain	Metallic Yellow
17	A	Imsco No. 2	Coarse Grain	Metallic White
18	A	Imsco No. 3	Medium Grain	Metallic White
19	B	Imsco No. 4	Fine Grain	Metallic White
20	C	Imsco White Muslin	Smooth	White
21	A	Minusa A	Medium Grain	Metallic White
22	A	Minusa B	Coarse Grain	Metallic White
23	A	Minusa C	Coarse Grain	Metallic White
24	A	Mazda-Lite	Fine Grain	Metallic White
25	B	Idealite-Grade 1A	Fine Grain	Metallic White
26	B	Idealite-Grade 1B	Medium Grain	Metallic White
27	B	Idealite-Grade 2	Fine Grain	Metallic White
28	C	Dalite Crystal White	Smooth	Blue Green
29	B	Dalite Gold Fibre	Fine Grain	Metallic Yellow
30	A	Dalite Silver	Fine Grain	Metallic White
31	A	Argus Crystal Bead No. 1	Medium Glass Beads	Yellow
32	B	Argus Crystal Bead No. 2	Fine Glass Beads	Yellow
33	B	Mirroroid	Fine Grain	Metallic White
34	A	Gold Ring	Smooth	Metallic Yellow
35	C	Half-tone	Smooth	White
36	A	Aluminium Paper	Smooth	Metallic White

B and C. Class A includes all those surfaces reflecting a large proportion of the picture light within a very narrow angle, and very little, by comparison, at greater angles. Class C includes those screens having high diffusive power and in Class B are grouped those surfaces which are intermediate between the extremes represented in classes A and C.

It should, however, be clearly understood that the line of demarkation between the three classes is not distinct. The classification is entirely arbitrary, and is made for the purpose of practical convenience.

CAUTION.—In examining and considering the data here tabulated **the exhibitor and projectionist should remember that two items only are considered, viz.: the reflecting power of the surface and its relative reflection at varying angles,** and that while these two things are of first importance, still there are other very desirable physical characteristics to be considered when the final selection of a screen is to be made. It may be found, for instance, that two or more surfaces are equally efficient for a certain auditorium, insofar as concerns reflective power and evenness of light distribution, but that one of them is found to have other characteristics superior to its competitors, such as a more substantial foundation (cloth backing) or the mounting or guarantee given with it. In such a case the final selection would of course be made on these latter points, reflection and distribution being equal.

TABLE 13

MISCELLANEOUS SURFACES

No.	DEGREES OF ANGLE									
	0	5	10	15	20	30	40	50	60	70
1	100	100	99.9	98.0	96.9	94.9	92.4	89.5	84.8	78.8
2	77.1	77.1	76.0	76.0	74.8	73.7	73.7	72.6	70.5	68.2
3	68.9	67.9	65.9	64.0	63.0	60.8	59.7	57.2	54.8	54.2
4	73.9	73.9	71.2	70.0	67.0	65.0	63.5	62.2	61.1	58.4
5	91.1	88.0	84.9	82.5	80.5	79.3	78.7	78.7	76.9	74.3
6	82.7	82.7	81.5	77.8	74.4	72.0	69.5	63.3	67.6	65.4
7	66.3	64.1	61.4	57.6	52.4	46.5	40.1	36.0	35.3	32.6
8	473	399	297	224	121	62.0	40.2	34.2	32.0	31.1
9	460	430	373	257	176	73.3	31.9	20.5	19.0	19.4

In Table No. 13 we have the characteristics of the first 9 surfaces in Table No. 12, none of which are commercial screens, but surfaces prepared for testing purposes. Selecting No. 1 for example, which by reference to Table No. 12, we find to be magnesium carbonate (the surface used for comparison), we find that, taking its reflective power at 100 when we stand directly in front of it, it shows 100 per cent. when we move to one side to an angle of five degrees, but at 10 degrees it has lost 1/10 of one per cent. of its brilliancy. At a 15 degree angle it has lost 2 per cent. of its brilliancy as viewed from straight in front or at an angle of 5 degrees. At 20 degrees its brilliancy drops to 96.9, or a bit more than 3 per cent., and so on until at the extreme angle of 70 degrees it has lost 21.2 per cent. and has 78.8 per cent. of the brilliancy shown from straight in front. On the other hand, taking surface No. 8, which we see by Table 11, is a sandblasted mirror, we find that from straight in front it has

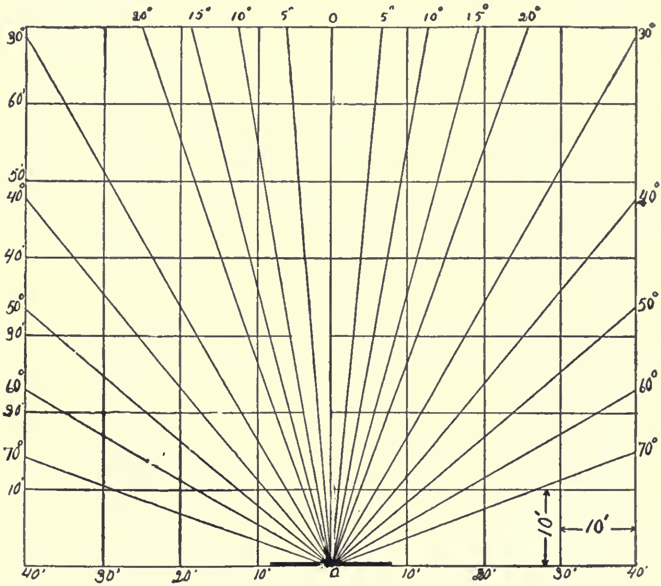


Figure 76.

a reflective power of 473 as compared with 100 for magnesium carbonate. In other words, the sandblasted mirror has reflective power almost four times that of magnesium carbonate when viewed from directly in front. If, however, we examine it at an angle we find that up to and somewhat beyond a 20 degree angle it retains its superiority over magnesium carbonate, though in rapidly decreasing percentage, but that somewhere between 20 and 30 degrees it drops below the magnesium carbonate, and at 30 degrees it has only

62 per cent. of its brilliancy, while at an angle of 70 degrees its brilliancy has dropped tc 31.1 per cent. Remember that all these percentages are percentages as compared to magnesium carbonate. In other words, it has enormous "fade-away" when viewed at an angle, though up to about 25 degrees it, while reflecting far below its straight-in-front brilliancy, still is equal to the magnesium carbonate surface, and anywhere within that range it is superior.

And now let us see exactly what that means. In Fig. 76 we have the representation of an auditorium 80 feet wide by 70 feet front to back. The individual can select the side lines which fit the width of his own theatre. Each of the small squares is 10 feet each way.

TABLE 14

COMMERCIAL SURFACES TESTED

No.	DEGREES OF ANGLE									
	0	5	10	15	20	30	40	50	60	70
10	268	256	215	168	120	64.8	34.3	21.8	16.8	14.2
11	300	284	255	206	167	93.9	52.2	26.5	17.0	13.3
12	208	203	188	161	134	85.0	53.3	33.0	22.4	18.3
13	177	174	165	143	122	85.9	53.0	33.0	23.8	17.7
14	72.9	72.2	70.8	70.5	60.4	68.9	68.1	68.8	67.0	64.0
15	286	273	229	173	129	66.0	33.0	21.4	15.2	13.7
16	311	288	234	180	125	66.0	35.0	21.7	15.6	14.0
17	230	220	200	171	141	83.1	47.4	29.6	20.3	16.0
18	208	197	177	152	127	80.6	47.9	34.3	24.3	19.9
19	186	183	160	146	120	79.8	47.9	31.3	22.2	17.6
20	66.4	66.3	65.2	63.6	62.4	61.0	60.4	60.0	59.3	58.9
21	326	308	270	204	157	76.0	38.6	25.7	15.0	12.5
22	355	339	274	207	149	71.7	35.8	21.7	15.0	12.8
23	315	298	256	203	151.	77.9	38.9	23.0	16.1	13.0
24	334	323	276	215	160	82.9	40.0	24.5	16.6	13.8
25	154	151	136	112	97.0	75.1	56.0	52.9	47.0	43.0
26	193	187	154	124	98.5	72.2	58.4	50.2	45.2	40.9
27	142	137	122	103	93.6	76.4	63.7	55.6	50.8	46.8
28	71.7	71.7	70.8	60.9	60.2	68.6	67.1	66.0	65.3	64.8
29	126	120	116	104	90.7	68.8	47.1	34.3	26.5	21.9
30	183	172	157	134	107	65.0	42.1	28.8	20.9	16.8
31	244	240	177	116	75.6	45.5	40.0	39.6	41.7	43.7
32	140	138	113	91.4	78.6	60.9	54.8	50.8	50.4	50.0
33	142	138	120	100	99.0	73.4	49.5	35.7	27.4	22.5
34	292	271	216	160	198	49.2	28.4	17.4	13.1	9.7
35	78.6	78.6	74.9	73.3	71.1	68.6	65.3	63.9	62.3	59.5
36	148	136	111	93.6	74.1	50.2	34.1	26.5	22.6	19.5

In table 14 we see that the angle of highest efficiency lies either within or very near to 20 degree lines for ordinary commercial screens, and that beyond 30 degrees all the surfaces except 14, 20, 28 and 35 (which same have low reflective and high diffusive power) fall off very rapidly, none of them standing much above 50 per cent. at 50 degrees angle. We may therefore conclude that for all the high reflective surfaces tested the range of efficiency lies well within the 50 degree angle, and it must be considered that beyond 30 degrees the difference between screen brilliancy in different sections of the house is such that it is apt to be noted by patrons, though this may be to some extent balanced by the preference some patrons have for a more or less brilliant picture.

Applying Fig. 76 let us suppose the exhibitor to have a house 40 feet wide by 70 feet deep. We have indicated a 16-foot wide picture by the thick black line. Following the 20 degree angle lines through the auditorium we see that considering a single point at the center of the screen at 20 feet from the screen, a space considerably less than 20 feet wide, or less than half the width of the house, falls within that angle, and even the 40 degree angle does not take in the entire width at 20 feet from the screen. At 30 feet from the screen the 30 degree angle does not take in the entire width of the house, whereas the 20 degree angle only includes a little more than 20 feet of its width.

But we consider only a point at the center of the screen, whereas the screen is 16 feet wide, so that the angle will include 8 feet more space on one side, but the patron seated on that side will be just that much worse off insofar as has to do with the other half of the screen.

Our purpose, however, is to indicate how Fig. 76 should be applied in practice, rather than to draw conclusions, since we shall, later, give you the conclusions arrived at by those making the tests. We give you Fig. 76 and we give you the tables showing the characteristics of the various surfaces. The rest is up to you, insofar as application of the data to your own local condition be concerned.

Remember that each one of the horizontal lines in Fig. 76 represents 10 feet of front to back depth, while each perpendicular line represents 10 feet of auditorium width.

The makers of the test drew their own conclusions, which same we shall present verbatim, and with no more comment than may be necessary to make the meaning clear.

CONCLUSIONS ARRIVED AT.—In order to facilitate the examination of the data, it will be well to separate them into their respective classes. After careful consideration of the characteristics of the screens and of the requirements of practical use, it was decided to define the range covered by these classes as follows:

Class A includes those screens which are adapted for use in theatres where the maximum angle of observation does not exceed 30 degrees; Class B includes the screens adapted for use where the maximum angle of observation does not exceed 50 degrees, while the Class C screens should be used in all cases where the angle of observation is greater than 50 degrees. The point should be again emphasized that these classifications are not rigid, but of an approximate character.

TABLE 15
CLASS A

Surface No.	20°		30°		40°		50°	
	Ratio	R	Ratio	R	Ratio	R	Ratio	R
8	3.91	305	7.62	235	11.8	194	13.8	165
9	2.61	339	6.30	270	14.4	217	22.4	183
34	2.70	209	5.94	167	10.3	137	16.8	116
31	3.22	159	5.48	127	6.10	108	6.17	96
22	2.38	265	4.96	216	9.92	167	16.3	151
15	2.21	218	4.34	178	8.70	147	13.4	134
21	2.06	253	4.30	207	8.47	172	13.2	145
10	2.23	205	4.14	169	7.82	140	12.3	119
24	2.08	253	4.02	209	8.35	174	13.6	147
23	2.08	245	4.00	201	8.10	167	13.7	141
11	1.80	242	3.20	202	5.75	172	11.3	147
16	1.69	228	3.20	184	6.03	152	9.75	130
36	2.00	112	2.96	96.4	4.34	83.3	5.59	73.2
30	1.70	151	2.82	128	4.35	110	6.36	87
17	1.63	192	2.77	165	4.85	141	7.77	121
18	1.64	172	2.58	150	4.25	128	6.07	112

Note: Columns marked "R" indicate mean (average) reflecting power within the entire angle.

After careful consideration of the subject, it was decided that the value of the ratio of the reflecting power measured at normal observation to that measured at the maximum angle of observation in a particular installation would serve as the most logical criterion by which to select the most suitable screen for any particular case.

This value will then represent the ratio of the brightness of the screen as observed by a person in the center of the auditorium to that of the brightness as observed by a person occupying a seat at the side and near the front. By keeping this ratio below a certain limiting value, satisfactory brightness will be obtained for all observers. This factor alone, however, is not sufficient for the classifying of screens according to their relative merits. The highest average reflecting power within the required angle from the normal will necessitate the least energy expenditure in the projecting system to produce a given screen brightness.

Assuming cases in which the maximum angles of observation are 20 degrees, 30 degrees, 40 degrees, and 50 degrees the values of the ratio of the reflecting power at normal observation to that at these various angles were computed for all screens and likewise values of mean reflecting power for the same limiting angles. These values are tabulated for the Class A screens in Table 15, those for the Class B screens in Table 16, and those for the Class C screens in Table 17.

TABLE 16

CLASS B

No.	20°		30°		40°		50°	
	R_o/R_{20}	R_a	R_o/R_{30}	R_a	R_o/R_{40}	R_a	R_o/R_{50}	R_a
12	1.55	179	2.45	155	3.91	135	6.30	117
19	1.55	161	2.34	141	3.88	129	5.95	109
13	1.45	156	2.06	139	3.34	121	5.37	106
33	1.43	123	1.93	111	2.87	99	3.97	88
26	1.96	151	2.67	131	3.30	115	3.70	104
29	1.39	111	1.83	100	2.68	90	3.68	79
25	1.59	130	2.05	115	2.75	104	2.91	94
32	1.78	112	2.30	99	2.56	89	2.76	82
27	1.52	120	1.86	108	2.23	98	2.56	91
7	1.26	60.3	1.42	56.7	1.65	53.5	1.84	50.4

Now it seems reasonable to demand that the ratio of the brightness on the axis to that at the extreme angle of observation sholl not be greater than 4.0. This value is decided upon after consideration not only of the variation in brightness as observed from various points in the auditorium, but also from a consideration of the fact that from a given point of observation the screen may appear of unequal brightness over its area. The danger of this inequality being serious increases rapidly as the value of the above mentioned ratio in reflecting powers increases. Assuming now that we adopt the value of 4 as the limiting value of the reflecting power ratio, it is possible from the figures in Tables 15, 16 and 17 to choose the best screen for any one of the cases considered. For instance, assuming that the maximum angle of observation is 20 degrees, it will be noted that all values in the under 20 degree ratio column of Table 15 are less than 4. Therefore from the standpoint of distribution any one of the screens in Class A will be satisfactory for use where the angle of observation does not exceed 20 degrees. In order now to obtain the maximum average brightness within this angle for a minimum current consumption it is only necessary to choose that screen, or screens, which shows the highest value in the column marked R. Next, assuming a maximum angle of 30 degrees we find that the first seven screens, Table 15, are excluded since the ratio of normal to extreme reflecting power is greater than 4. Beginning with No. 11 we may then choose screens showing the highest average reflecting power for the range 0 to 30

TABLE 17

CLASS C

No.	20°		30°		40°		50°	
	Ratio	R_{m20}	Ratio	R_{m30}	Ratio	R_{m40}	Ratio	R_{m50}
6	1.10	79.8	1.15	77.7	1.19	76.1	1.30	74.6
35	1.10	75.3	1.14	73.5	1.20	71.7	1.23	70.4
3	1.09	65.8	1.13	64.6	1.15	63.5	1.20	62.5
4	1.10	71.2	1.13	69.6	1.16	68.3	1.19	67.3
5	1.13	85.4	1.15	83.5	1.15	82.7	1.15	82.0
1	1.03	90.0	1.05	97.9	1.08	96.8	1.12	95.5
14	1.05	71.0	1.06	71.0	1.07	70.0	1.07	67.0
20	1.06	64.0	1.09	64.0	1.10	52.0	1.10	54.0
28	1.02	71.0	1.03	70.0	1.04	70.0	1.07	69.0
2	1.03	77.1	1.05	76.2	1.05	75.6	1.06	75.0

degrees. (Author's Note: This average was found by adding together reflector powers for 0, 5, 10, 15, 20 and 30 degree angles and dividing by 6.) When the maximum angle of 40 degrees is considered we find no screen in Class A which does not exceed the limiting value of 4 for reflecting power ratio. We therefore turn to Table 16, and there find that all values of the reflecting power ratio are less than 4. We may therefore select from Class B that screen which has the highest reflecting power for the 0 to 40 degree range. In case of the 50 degree limiting angle, three of the Class B screens are automatically excluded, and it is only necessary to select from the remainder the one having the highest average reflecting power for the 0 to 50 degree angle.

The Film

THE film is a strip of celluloid 1⅜ inches wide by from 5½ to 6 one thousandths of an inch in thickness. In the process of making the celluloid is originally in strips about 2 feet wide by 250 to 300 feet in length. These wide strips are passed through a machine which spreads upon one side a coating (negative or positive, according to the use to which the stock being treated is to be put) of photographic emulsion. The emulsion is a part of the thickness of the film as above given.

Having received its emulsion coating the film is passed through another machine which splits it into ribbons 1⅜ inches wide, and these ribbons become the film stock which is purchased by the photoplay producer.

The negative stock is first perforated, then it is placed in a camera having an intermittent movement, a revolving shutter and a lens, the whole mechanism being very similar in its action to that of the motion picture projector, except that the mechanism and film are enclosed in a light tight box, or casing. Each ¾ of an inch of the negative is successively exposed to the light by the camera mechanism, and what is nothing more nor less than a "snapshot" photograph is impressed thereon. The exposures are supposed to be at the rate of 16 per second, but in practice camera speed varies over a rather wide range, running as high as 80 feet of film to the minute in some instances.

After exposure the negative is removed from the camera, developed, fixed and dried by much the same chemical process as is any ordinary Kodak negative, though the mechanical methods necessarily differ widely from the Kodak process, since the negative film will be anywhere from ten to 300 feet in length.

The negative is then projected to a screen, so that the director may check up his work, make the scene over again if necessary, or cut out any undesirable portions. When the negative is finally in acceptable form it is placed in a printing machine in contact with a strip of positive film (positive and negative film are precisely the same, except that a different grade or kind of photographic emulsion is used) and by means of another intermittent movement and revolving shutter, but without the lens this time, it is exposed to artificial light of fixed, known power, each picture being exposed for the small fraction of a second. The positive film is then developed, fixed and dried, after which it is sent to the assembling room, where the various scenes constituting a complete photoplay are arranged in sequence, joined together, the titles and sub-titles inserted, and it finally becomes the "reel of film" with which we are all familiar.

The foregoing, of course, only very roughly describes the various processes through which the film passes in the course of its making and the making of the play. To describe all the processes in detail would require a book of goodly size in itself.

The perforating usually is done by the producer, though perforated stock may be purchased from the film stock maker. There are 64 perforations to the foot on either side, or 4 on each side to each picture. Of late years film perforation has been brought up to a state of almost absolute mechanical perfection. It is one of the processes which must be done with great accuracy, else there will be unsteadiness of the picture on the screen.

THICKNESS OF FILM STOCK.—It is important that film stock be of unvarying, standard thickness, since thin stock has a decided tendency to produce unsteadiness of the picture on the screen, besides being unduly weak and short lived.

STANDARD PERFORATION AND OTHER FILM MEASUREMENTS.—At present (1922) there are several shapes of sprocket hole; also the dimensions of various sprocket holes vary. The Society of Motion Picture Engineers has adopted as standard the dimensions shown in Fig. 77.

We quote the following from a paper read by Donald Bell before the Society of Motion Picture Engineers at its New York City meeting in 1916. Mr. Bell is, we believe, the best living authority on such matters.

"It is accepted as settled fact that the maximum shrinkage of motion picture film is .0937 of an inch per foot. Painstaking experiment warranted the conclusion that a gauge length of 11.968 inches for 64 holes would insure that accuracy of perforation necesary to perfect results, and at the same time make due allowance for the shrinkage of film. The following computation shows why we have adopted 11.968 inches instead of 12 inches as the standard for a perforation gauge measuring 64 holes:

"Assuming the outside diameter of the sprocket of all standard projectors to be .9375 (15/16) of an inch, then the circumference would be 2.94525 inches. As a standard motion picture film has an average thickness of .0065 of an inch, the pitch diameter of the sprocket will be found to be .9375 of an inch, plus .0065 of an inch, or a total of .944 of an inch.

"Pitch circumference is 3.1416 × .944 = 2.965704 inches. Circular pitch equals 2.965704 ÷ 16 (number of teeth on a sprocket) = .1853+ of an inch.

"The standard perforating gauge being 11.968 inches for 64 holes, and the maximum allowance for shrinkage being .09375 (3/32) of an inch for 64 holes, therefore 11.968 inches minus .09375 of an inch, or 11.8743 inches, is the average length of shrunken film measuring 64 sprocket holes. The pitch of the film, or length per hole, is 11.8743 divided by 64, or .18553 of an inch. Pitch of sprocket .1853 of an inch. Pitch of film .18855 of an inch."

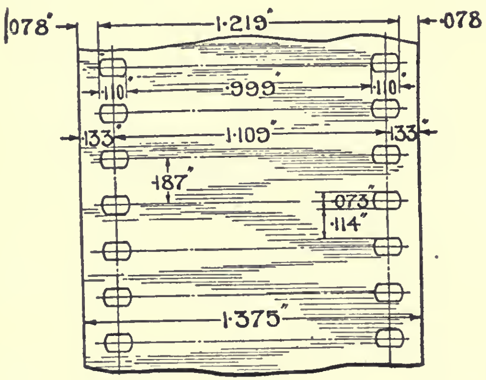


Figure 77.

Pitch means distance from center to center.

The dimensions shown in Fig. 77 represent good practice, and it is to be hoped that in the near future all film dimensions, including the sprocket holes, will be thoroughly standardized along these lines.

DAMAGE TO FILM.—When film is new, pliable and decidedly tough, its celluloid base is at that time least susceptible to damage, but, on the other hand, that is the time the photographic emulsion is most easily damaged. By unintelligent handling of the film, lack of care in the adjustment of the projector, improper lining of the two elements of the rewinder, too-rapid speed of rewinding and the improper storing, great damage is caused, which mounts into the tens of thousands of dollars a day, and this unnecesary damage must, in the very nature of things, be added to the "overhead" expense of the industry, and finally be paid for in the form of increased film rentals.

A very large percentage of the scratches in the photographic emulsion of film, which same fill up with dirt and form the "rain" with which we are all familar, is caused by improper rewinding, particularly the process known as "pulling down."

This latter consists of holding one reel stationary while the other is revolved to tighten the film roll, which operation causes all the various layers of film to slip upon each other under much friction, and since there are always more or less particles of dust and dirt adhering to the film, scratches are the inevitable result.

Injury to sprocket holes is, for the most part, due to undercut or hooked sprocket teeth (see general instruction No. 7, Page 602) to too much pressure by the tension shoes

Figure 77A

of the projector (see general instruction No. 9, Page 603) and to excessive takeup tension.

As a general proposition we believe that most projectionists and some operators are at least reasonably careful in handling and repairing film. In many theatres, however, rewinding, threading the projectors and repairing film is made the duty of a more or less irresponsible usher or reel boy, whose main idea is to get the job finished in the least possible time. These boys do not understand the damage done by careless work; also undoubtedly many of them do not care. If a splice is to be made, their one and only idea is to get the film ends stuck together. In their view the quickest way is the best way, regardless of after-results. Badly matched splices, misframes, splices without the emulsion scraped off or only partly scraped off are the regular thing where an usher or reel boy does the repairing. It is no uncommon thing where this sort of irresponsible help is placed in charge of repairing film for an exchange to receive film back "spliced" with a nail or a pin. Even when the projectionist does the rewinding and repairing he is, in all too many cases, expected to do it while projecting a picture, hence must neglect either one thing or the other.

In the majority of cases the real underlying fault is in the failure of the theatre management to employ sufficient competent help in the projection room. Film repairing should, under no circumstances, be done by any other than a thoroughly competent, responsible projectionist or a regularly employed projectionist apprentice.

Injury to film in passing through a modern motion picture projector is invariably due either to the bad condition of the film itself, to the false economy of a theatre management which refuses necessary repairs to the projector, or to the lack of knowledge, carelessness or laziness of the projectionist himself, which results in improper tension adjustment, hooked sprocket teeth, etc.

Film exchange managers seem, in all too many cases, not to realize that the sending out of film in poor condition not only is an outrage against the producer, against the projectionist who must use it, against the theatre management which is paying for films in good repair, but also against the audience which pays money to see at least a reasonably perfect performance. The average exchange manager does not seem to understand that sending out film in poor condition is a direct invitation to more and greater damage, since a

loose splice is likely to catch on a sprocket idler and split anywhere from one to four feet of film before the projector can be stopped, especially in houses where the projectionist is obliged to rewind and do other chores while his projectors are running the show.

Splices in which sprocket holes are not properly matched are likely to clamp the sprocket teeth, thus causing a jump in the picture and perhaps the loss of a loop, or they may grip the teeth of the sprocket and wrap around it, particularly if the sprocket teeth be under cut or somewhat hooked. Split sprocket holes will ofttimes catch on a sprocket idler, and a section of the edge of the film will split off, even if nothing worse occurs.

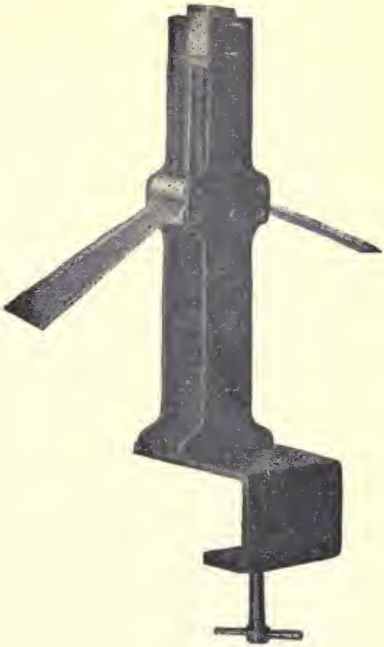


Figure 77B

EMULSION DEPOSIT.—Much damage is done to first run film by means of emulsion deposit (see general instruction No. 10, Page 604). This trouble is greatly aggravated if the projectionist carries too tight a gate tension.

In fact there are numberless ways in which film may receive damage. It is a fragile product, and a product which must be in absolutely perfect condition if there is to be a perfect picture on the screen.

FILM WAXER.—When using first run films upon which the emulsion is soft there is always the inclination of emulsion to rub off and deposit on the tension shoes or springs. The best method of preventing this is to place a small amount of suitable wax on the sprocket hole tracks.

There are at least two excellent machines on the market which accomplish this purpose, viz.: "The Werner film waxer, illustrated in Fig. 77A made by the Werner Film Projector Manufacturing Company, St. Louis, Mo., and the Weiss Film Waxer, made by Adam Weiss, Cleveland, Ohio.

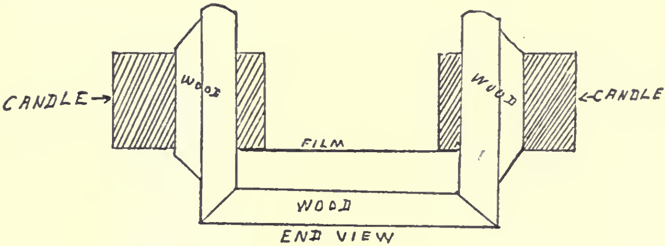


Figure 77C

This latter is illustrated in Fig. 77B. Both are very efficient devices.

It is quite possible to make a home-made waxer which will work very well. Such a device is illustrated in Fig. 77C. The construction of the device is made clear in the illustration. Ordinary tallow candles may be used or cylinders of wax may be made by using a tin mould of suitable diameter, open at both ends. Pour this full of melted paraffine wax, which may be had at any drug store and most grocery stores. Let it cool and then slightly heat the receptacle whereupon the wax cylinder may be pushed out.

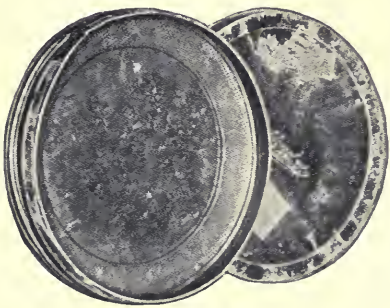


Figure 77D

Humidor can for film. May be used for keeping film pliable, or for resaturating old, dry film with moisture, though if used for the latter purpose film must be wound very loosely.

MENDING THE FILM, i. e., making splices in it, is a matter deserving of very much more consideration than it apparently has received.

Poorly made splices are a source of great and unending annoy-

ance to all concerned, as well as the source of literally enormous damage to film.

It has even been claimed by competent projectionists that badly made splices are a greater source of damage to film than all other things combined. And there is good ground for their claim, too, because a poorly made splice may cause damage in many ways, not the least of which is to start a film split, which may continue for several feet before the projector (and the show) can be stopped.

One source of very great annoyance is the imperfect

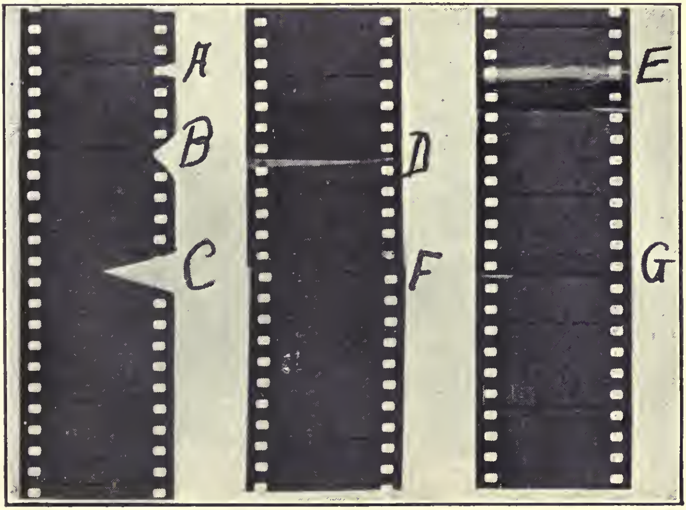


Figure 77E

A and C are broken sprocket holes improperly notched, C being very bad, indeed. B is properly notched except that the notch spreads too wide and weakens adjoining holes. D and E are examples of atrociously made splices. D is half an inch wide and not properly scraped. F is crooked and E is an example of slovenly work in scraping the emulsion off. G is a mis-frame and is otherwise improperly made.

matching of sprocket holes so common where splices are made by hand. Imperfectly matched sprocket holes are apt to cause the following troubles: (a) Picture jumps as the splice goes through because the sprocket holes are too small to allow sprocket teeth to set properly, hence film is lifted away from the sprocket. (b) A too-small sprocket hole locking on sprocket tooth and pulling film around under sprocket. (c) Film running off sprocket. (d) Intermittent sprocket teeth "climbing" one or more holes, thus shortening or "losing" one of the loops, and throwing the picture out of frame on the screen. (e) Side movement of picture due to crookedness of film as a whole. (f) Takeup, pulling film over lower sprocket, thus shortening or losing the lower loop.

All this is apt to occur, even though the sprocket holes be perfectly matched on one side, if they be imperfectly

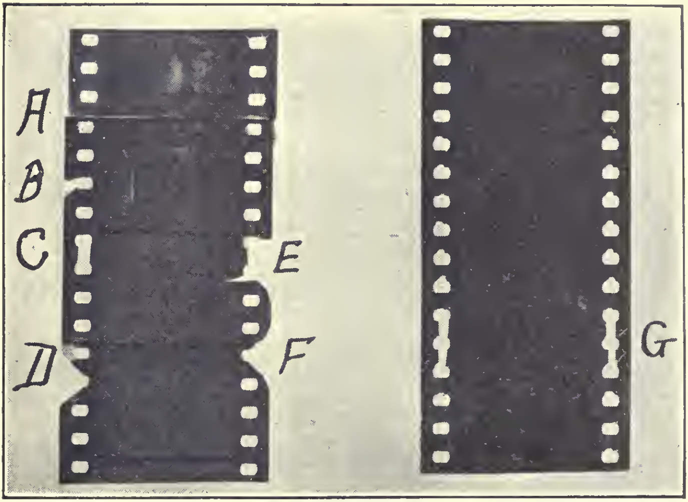


Figure 77F

A is a splice which may cause sprocket holes to clamp sprocket teeth, with consequent jump of picture on screen, or even the pulling of the film around sprocket. It certainly will cause side movement of picture on screen. At B is a broken sprocket hole which has been improperly notched, proper shape of notch being shown at D or F, though notches D and F are correct as to shape only. They should not have been made either in or so near a splice. As the injuries to the film now are all that portion ,from A to D should be cut out and a new splice made. At G a splice is necessary because the injury includes three successive sprocket holes.

matched on the other side, because in that event the hole or holes on one side will be small, and the film, as a whole, will be crooked at that point.

You will therefore see the great importance of matching

the sprocket holes perfectly, which in practice means using either a splicer or some sort of metal teeth for a guide.

In many projection rooms the practice is to make splices with the unaided fingers. Film cement welds, more than it glues the film together, hence evenly applied pressure, of considerable amount, is necessary to the making of a perfect joint, and while it is quite possible to apply sufficient pressure with the fingers, it certainly cannot be applied evenly, with the almost inevitable result that even though the finger-made splice be strong in part of its width, it will be weak in another part.

In Fig. 78 you see a compact and very effective film splicer. It is made by the General Machine Company, New York City. We have had this device tested and have tested it personally. It is excellent and well worth its price, which latter is quite reasonable. We advise the installation of this device or a similar one in all projection rooms, **and that the making of hand-made splices be absolutely prohibited.**

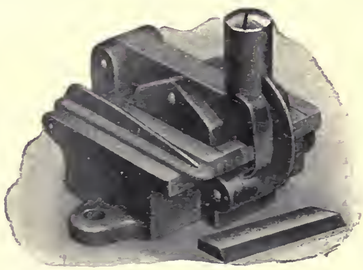


Figure 78.

WIDTH OF SPLICE.—A too-narrow splice is apt to be weak, and a too-wide one objectionably stiff. Provided a good film splicer be used, there is no necessity for a splice of greater width than .125 (⅛) of an inch. Such a splice will be amply strong and at the same time sufficiently flexible to go through the projector without any indication of its presence in the film showing on the screen.

There has been a machine used by some producers which makes a splice about 1/32 of an inch wide. **There is no practical advantage in the use of such a splice in positive film, and these very narrow splices have been an unending source of annoyance to the projectionists.** The maker of the machine places the blame on those handling it, but that is no excuse, because a machine which does not function well in the hands of the employees who must be depended on to handle it is not a good machine, notwithstanding the fact that it would produce good results if expertly operated.

Anyhow, as we have said, there is no advantage in such a narrow splice in positive film.

There should always be one full sprocket hole in the stub end, as at A, Fig. 79, and stub end A should never exceed .125 (⅛) of an inch in width, unless it be necessary to slightly exceed that width in order to avoid cutting into the sprocket hole.

MAKING THE SPLICE.—Cut the film ends as per Fig. 79, end B being trimmed exactly on the dividing line (frame line) between two pictures, the other end with a stub end (A Fig. 79) extending .125 (⅛) of an inch beyond the frame line indicated by dotted line.

It is of the utmost importance that every particle of emulsion be scraped off stub end A; also that the back, or celluloid side of end B be scraped lightly in order to roughen the celluloid and remove all dirt and grease.

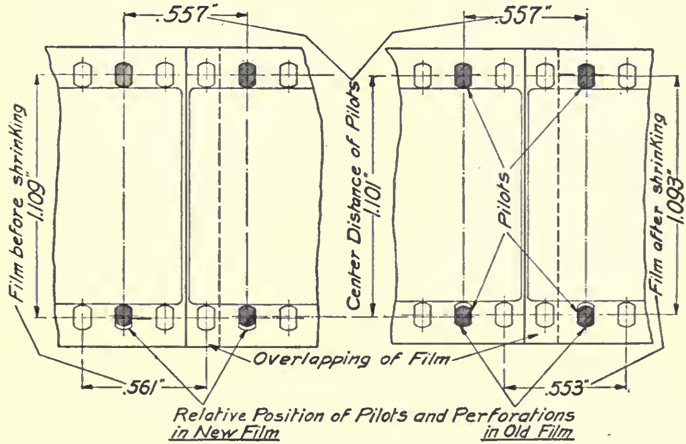


Figure 78A.

Some prefer a very sharp knife blade and some a safety razor blade fixed in a convenient holder, to scrape with. What is used does not matter, provided a thorough job be done, without removing any appreciable portion of the celluloid itself, since that would weaken the film stock.

OF IMMENSE IMPORTANCE.—It must be understood and remembered that the emulsion covers the entire film, from outside to outside, and that, except for special cements, film cement will not adhere to emulsion, and will not penetrate it and weld the celluloid beneath—for film cement does not merely stick the surfaces of the film together, but actually welds them, if the cement be a good one. And this is right where the greatest sin is committed in making splices.

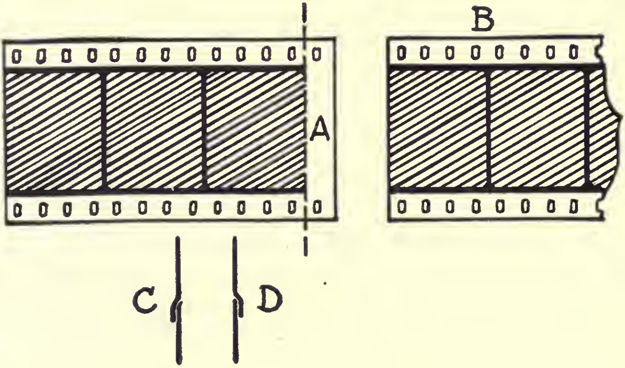


Figure 79.

Either from laziness, carelessness or lack of time to do the job right, or because they fear to break the edge of the film at the sprocket hole, many do not scrape the emulsion off thoroughly, or even do not scrape it off at all around the sprocket holes, RIGHT WHERE THE HEAVIEST STRAIN ON THE SPLICE WILL COME. The inevitable result is that such splices either never are cemented together at their edges, or else very quickly come loose at the sprocket holes, whereupon there is, sooner or later (usually sooner), trouble.

SCRAPE TO A STRAIGHT LINE.—Stub end A, Fig. 79, should be scraped to a straight line at the frame line, as per dotted line, and the use of a straight edge is imperative to this end. Too much trouble? Well, if you think so, then you ought not to be allowed to handle film at all. Carelessness in this respect means flashes of white light on the screen.

Having scraped the end of the film as directed, apply cement all over the scraped surface of stub end A, but do not smear on too much, because surplus cement is very apt to adhere to the tension shoes and cause trouble. The actual method of placing the ends together will, of course, vary according to whether or not a splicer is used, but in any event one must work fast, match the sprocket holes of the two ends perfectly, and then apply tolerably heavy and evenly distributed pressure for say five seconds.

Every cement bottle should have a small brush, the handle of which is attached to the under side of the cork, or else thrust through it. When you buy cement, accept none without the brush, unless you already have an empty bottle thus equipped.

FILM CEMENTS.—The Eastman Kodak Company has on the market a film cement which is, so they assert, made from tested chemicals, which means that every lot will be exactly the same. This cement is equally good for either inflammable or non-inflammable film. Certainly the Eastman company, being the largest manufacturers of film in the world, ought to know what is required in a film cement, and if tested chemicals only are used, that should be sufficient guarantee to us all that the cement is good.

We, therefore, recommend to you the cement made by the Eastman company. You may get further information in an advertisement we are advised they propose to run in the back of the book.

FORMULAS.—In presenting there formulas please understand we do NOT vouch for their excellence. They are all good when made from proper chemicals, but experience has amply proven the fact that when a certain formula for film cement is made up at different times from chemicals purchased from various local drug stores, there not infrequently is a wide variation in results. We therefore present cement formulas subject to that notation.

ORDINARY.—For non-inflammable stock, ½ pound of acetic ether, ¼ pound of acetone merch, in which dissolve 6 feet of non-inflammable film from which the emulsion has been removed. (See Removing Emulsion, Page 290.)

For inflammable film, a piece of the film 3 inches long dissolved in 1 ounce of acetic ether is a satisfactory cement, but it will not work on N. I. (non-inflammable) stock. In dissolving the film, in either case, first remove the emulsion and then cut the film into fine strips.

ACETONE CEMENT.—Four ounces of acetone; ½ ounce ether; 6 inches old film, from which remove the emulsion and cut into strips.

ANOTHER FORMULA.—Equal parts of amyl acetate and acetone. Will not turn white on film, and will not dissolve the film as ether will. Works on all kinds of stock. Best used with an all steel 3 flap film mender. Can be used by those making patches by hand if worked rapidly. Scrape film, use small camel hair brush; keep bottle tightly corked when not in use.

STILL ANOTHER.—One ounce collodion; 1 ounce banana oil or bronzing liquid; ½ ounce ether. For Pathe hand colored films, ½ acetone and ½ ether.

N. I. CEMENT.—For non-inflammable film add 1 part glacial acetic acid to 4 parts of flexible collodion to any of the film cements. It is satisfactory for either N. I. or regular film.

FILM REEL CONSTRUCTION.—Immense amount of damage has been done to film in the past by reason of the flimsy construction of reels. The earlier practice was to use a wooden hub 1½ inches in diameter, upon which was mounted two rather flimsy, more or less open, metal reel sides. The hub itself had little stability, its diameter was absurdly small, and the reel sides entirely inadequate to withstand the abuse to which they were, in ordinary practice, subjected.

Of late years there has been a tendency to increase the diameter of the hub to about 5 inches, and to make it of metal instead of wood. The sides of most reels we have as yet seen are still entirely too flimsy. They bend too easily, and a bent reel is a prolific source of damage to film, not only by reason of the fact that there is the possibility of the bent reel rubbing on the sides of the upper magazine, thus acting as a brake and subjecting the film to a heavy strain between the upper sprocket and the reel, particularly at the last end of the run, but also by reason of the fact that the bend may be inward, thus pinching the film between the two sides, both while being projected and in the process of rewinding.

In order to save in first cost of reels and shipping weight, film exchanges have favored a light weight, flimsily built, cheap reel, notwithstanding the fact that the damage done to film by small hubs and bent reel sides, amount to many time the "saving" accomplished by the foolish proceduce.

We strongly recommend to exhibitors that they equip their projection rooms forthwith with a full complement of the best reel obtainable, and that, if necessary, they oblige

their projectionists to use them. (See Projection Room Reels, page 322.)

In considering this recommendation exhibitors should remember that all damage to film which tends to shorten its useful life must inevitably come back to the exhibitor in the form of increased film rental, hence the less damage done to the films while in their theatre the less will be the general overhead expense to be charged back in this way.

SIZE OF REELS.—The present trend is to use 2,000 foot reels in the process of projection, though for the most part film is still shipped on 1,000 foot reels. In considering whether it is the better practice in projection to use 1,000, 2,000 or 3,000 foot reels, we must take into consideration the fact that it sometimes is better to go around a stone wall than to climb it or try to push it over with your hands. The 1,000 foot reel offers a somewhat less liability to damage in the process of rewinding and handling, and a less possibility of fire loss in case of fire at the projector, but the fact remains that in the majority of large modern theatres 2,000 foot reels are used in projection. That is the condition, and we may as well make the best of it. We do not mean to infer by this, however, that there is any very serious objection to a 2,000 foot reel, since with modern projectors fires are of rare occurrence, and as a general rule the 2,000 foot reel (not film, but the reel itself) is kept in better condition than is its smaller brother, so that perhaps the added tendency to damage in rewinding with small reels in poor condition is thus counterbalanced. There is, it seems to us, no real need for a 3,000 foot reel, and there are very serious objections to its general use.

But whatever the capacity of the reel, one thing is important, viz.: Its sides should always extend over the film roll by at least ¼ and preferably ½ an inch, because in this way the whole film roll will be protected by the metal sides of the reel. The overloading of reels has been a source of much annoyance to projectionists and great damage to film, though this particular evil is not so much practiced of late. Even film exchanges are apparently slowly learning to exercise a little horse sense, in some directions at least, in the care of their property. The evil of the overloaded reel is three-fold. (a) That portion of the film outside, or above the sides of the reel, is absolutely unprotected, hence liable to injury in many ways other than the likelihood of its slipping off, to the exasperation of the projectionist and the possible delay of the show while it is being wound on again, to say nothing of probable damage through contact with a more or less dirty, dusty floor. (b) (Very serious indeed) the increased temptation to "pull down," and pull down good and hard, too, in order to get as much of the film inside the reel sides as possible. (c) The fact that the film may rub against the magazine, thus scratching it and possibly interfering seriously with the operation of the takeup, incidentally requiring an excessively tight takeup tension, which is worse than bad, and a prolific source of damage to the first part of the film through scratching and the tendency to pull the film over the teeth of the lower sprocket, thus injuring the sprocket holes, scratching the film and losing the lower loop.

HOW MUCH FILM WILL A REEL HOLD?—We have been asked many times how to figure what number of feet a reel of given diameter, with a hub of given diameter, will hold.

This is a question which cannot be answered exactly, because it will depend upon how tightly the film is wound. It is possible to figure it, though we cannot recommend the process for accurate results.

First find average length of film layers, which is done by adding together the circumference of the reel hub and the outside circumference of the film roll, when the reel is full, and dividing the result by two. The result will be the average length, in inches, of all layers of film.

Next subtract half the diameter of the reel hub from half the diameter of the film roll. The result will be the number of inches of film, or the "depth" of the film roll from outside diameter to hub.

Next you may either count the number of layers of film in one inch, or you may divide 1,000 by 6 (six thonsandths of an inch being the thickness of film and emulsion), which will give you the number of layers of film per inch, provided the film be very tightly wound. Counting is best, though, and even that will be unreliable, because of variation in tightness of winding.

You now multiply the number of layers of film per inch by the number of inches of depth in the film roll, and multiply that result by the average length of the layers. Divide this by twelve, to reduce to feet, and the final result will be the number of feet of film on the reel, or which a reel will hold, as closely as it can be figured.

LEADER AND TAIL-PIECE.—For several reasons it is essential that there be a "leader" and "tail-piece" at the ends of every reel of film, including the multiple reel feature. The leader not only serves to protect the title from damage, but it enables the projectionist to thread his projector with one of the first frames of the main title over the aperture, whereas otherwise by the time the projector was threaded much of the main title would be past the aperture. Then, too, in threading into the takeup it is frequently desirable, if not necessary, to fold an inch or so of the film over on itself. By so doing it is made stiffer and more easily thrust under the reel spring, also it is more certain to "stay put." This means that the film will soon break off where it is folded, which causes a gradual wasting away of the main title, if there be no leader, and soon there will either not be sufficient title, or a new one will have to be provided for. If, however, there is a leader, then there is no wasting of the main title, and leader costs very much less than title. Another reason why leader should be used is that at the end of the process of rewinding the film often slaps around anywhere from one to a dozen times before the reel is stopped, and if there be no leader to receive the brunt of this rough treatment the title itself is injured. Leader should be at least 36 inches long, and 5 feet is very much better. Old film may be used for leaders, but the better plan is to use film upon which no photograph has been impressed, but which has been exposed in the printing and developed quite dense. This has the advantage of allowing the man who is too lazy to thread in frame to frame up before the main title comes on.

As a matter of fact no competent projectionist who has pride in his work will even think of threading out of frame, but there are a considerable number of operators, or miscalled projectionists, who still persist in sloppy methods. They have no pride in their work, and no right place in a projection room. Instead of being paid for their work the motion picture industry would do better to, if necessary, pay them to remain entirely outside of all projection rooms.

Let us here remark that some projectionists use a stereopticon title where the film title is too short to show. A better plan than this is to punch a hole about ⅛ of an inch in diameter in the center of the dowser, then before starting the projector, with the dowser down and the revolving shutter of the projector turned until the projection lens is open, raise the automatic fire shutter and project the film title to the screen. If the hole in the dowser be not too large (1/8 inch in diameter ought to do the trick all right) there will be absolutely no danger of injury to the film, and at the same time the title will appear on the screen plenty plain enough to be read by the audience. It is a much better plan than using a stereopticon slide.

Our reason for advising a leader and tail-piece on multiple reel features is found in the fact that whereas they will slightly inconvenience the projectionist of the large theatre, who joins his 1,000 foot reels together in 2,000 foot reels, they will be very necessary to the projectionist who projects from 1,000 foot reels.

AN OPAQUE TAIL-PIECE is of great importance, because we know of nothing in all the realm of projection so thoroughly disillusioning as the flashing of white light on the screen at the end of a reel. The careful, competent projectionist will stop his projector, or will change over to the other projector before the end of the reel comes. This man will

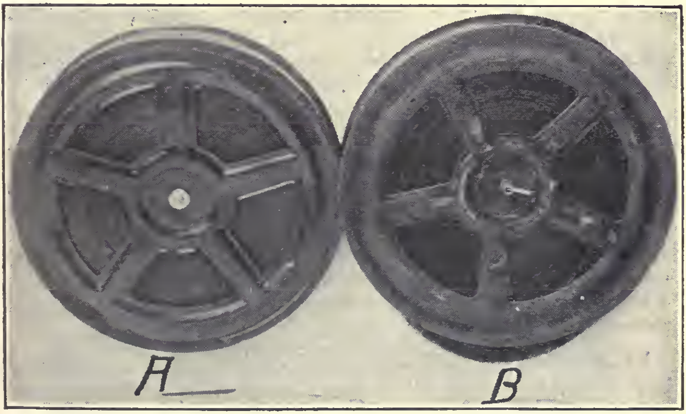


Figure 79A.

Graphic illustration of a reel rightly rewound A, which may only be done by applying considerable and even brake friction to the reel from which the film is being rewound, and a reel improperly rewound, which means without the tension supplied by brake action on reel from which film is being wound. Film rewound as per reel B is liable to serious damage in several ways. It is "pulling down" to tighten films rewound as per B which causes nine-tenths of the "rain."

need no tail-piece, but the sloppy man who either does not care or is too lazy to do his work right, and who lets the end of the film pass the aperture before changing over to the second projector should have an opaque tail-piece on all his reels,

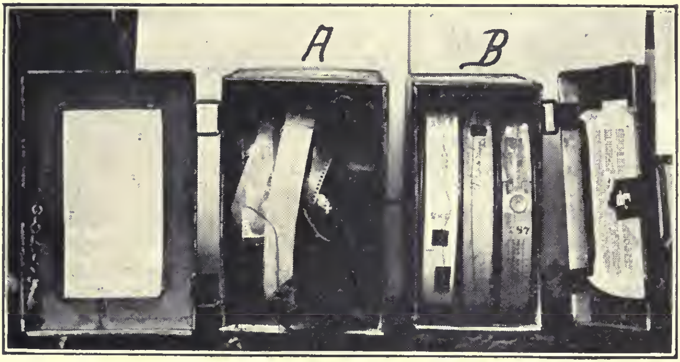


Figure 79B.

At A we see an improperly packed shipping case. Resultant possible damage to the films is apparent. At B we see a properly packed shipping case. Remarks seem unnecessary.

so that instead of the screen going white it will go dark, provided, of course, he is sufficiently on the job to stop the projector while the tail-piece is over the aperture.

The allowing of the entire film to run through and the flashing of the white light on the screen at the end of the run is very crude work indeed, so crude that no man deserving the title projectionist would even think of doing it. Even the "operator" should be ashamed to do such a stupid thing.

FILM INSPECTION—The projectionist should, so far as is practicable, repair all damage, other than ordinary wear he himself inflicts upon film while it is in his possession.

It is the duty of film exchanges to thoroughly inspect and repair all films before they are sent to a theatre. THE PRICE EXHIBITORS PAY FOR FILM INCLUDES THIS SERVICE, AND WHEN AN EXCHANGE FAILS TO PERFORM IT, IT JUST TO THAT EXTENT IS NOT DOING ITS DUTY, MODIFIED ONLY BY THE FACT THAT IN OCCASIONAL INSTANCES WHERE THERE IS IN-

SUFFICIENT TIME TO MAKE REPAIRS THE EXCHANGE MAY BE EXCUSED, PROVIDED IT PLACES IN THE BOX WITH THE FILMS A CARD STATING THAT THE FILMS HAVE NOT BEEN EXAMINED AND REPAIRED, AND INSTRUCTING THE PROJECTIONIST TO MAKE REPAIRS, SENDING TO THE EXCHANGE HIS BILL FOR THE SERVICE.

BY NO STRETCH OF IMAGINATION CAN IT BE DEEMED THE DUTY OF THE PROJECTIONIST TO REPAIR FILMS RECEIVED FROM AN EXCHANGE, AND WHEN, IN CASE OF EMERGENCY, IT IS NECESSARY FOR HIM TO DO SO, HE HAS THE PERFECT RIGHT TO EXPECT TO BE PAID BY THE EXCHANGE, AT A REASONABLE RATE PER HOUR, FOR HIS SERVICE, SINCE HE IS NOT A FILM INSPECTOR AND REPAIR MAN, BUT A PROJECTIONIST.

PERFECT PROJECTION IS IMPOSSIBLE OF ACCOMPLISHMENT UNLESS THE FILM BE ITSELF IN PERFECT MECHANICAL CONDITION, AND A FILM IS NOT IN PERFECT MECHANICAL CONDITION WHEN IT HAS WIDE, STIFF, OR LOOSE SPLICES, MISFRAMES, STRAINED OR RIPPED SPROCKET HOLES RAIN, ETC., OR WHERE ITS SURFACE IS SMEARED WITH OIL. THESE FAULTS ARE PROLIFIC SOURCES OF POOR SCREEN RESULTS.

Figure 80.

It is a well known fact that many film exchanges make only the most superficial inspection of film, and either very little or no repairs at all. The underlying cause of this is, we believe, an endeavor by film exchanges to get too much work out of the film, coupled with a deliberate attempt on the part of the exchange to force the projectionist to do their film inspection and repair work free of charge, because they are unwilling to expend the necessary amount of money in the employment of either enough or competent inspectors. In many exchanges we can personally bear testimony to the fact that "inspection" and repairs consist of a man or girl rewinding the film at top speed, stopping only when the film is torn clear in two. We might incidentally add that these "inspectors" often used crooked reels and rewinders which are badly out of line, under which condition by rapid rewinding of the film they actually do more damage to the film than their "repairs" amount to.

The ordinary exchange inspection does not detect anything except the very worst faults, such as long stretches of ripped sprocket holes, a patch loose half way across the film or the film torn entirely in two. Minor faults cannot possibly be detected by the whirlwind inspection process in vogue in very many exchanges.

We are well aware that the question of inspection and repair presents a problem of several angles, and one which is not at all easy to adjust. However, the statement that there is absolutely no excuse whatsoever for the utterly miserable condition in which many films are received by the projectionist cannot be successfully contradicted.

We are heartily in favor of projectionists demanding overtime for inspecting and repairing film when they are received in bad condition. We are unable to understand by what process of reasoning either the exhibitor or exchange justifies his demand that the projectionist do the work without remuneration.

FILMS ON A CIRCUIT.—Where films are used on circuit it should be a point of honor with each projectionist to send the films away in as good condition as they are received. DON'T leave it to your brother projectionist who gets them next to repair the damage YOU have done.

FILM NOTCHING PLIERS.—For a long time there has been on the market a cutting plier with which broken sprocket holes may be notched as per Fig. 80.

This tool should be in the hands of every exchange inspector and projectionist. It is the invention of A. Jay Smith, Cleveland, Ohio.

WHERE TO KEEP FILMS.—Film should be kept near the floor of the projection room, since near the ceiling it is much warmer. It should be kept in a metal box having compartments for each reel, and one compartment below to hold a wet sponge or water. The film should be treated with a little glycerine once in a while, but this is only accomplished by having the film in actual contact with the liquid, as per directions further on. The glycerine is for the purpose of keeping the film soft and pliable, which it does by reason of the fact that it has the property of rapidly absorbing and retaining moisture.

Should water, by any accident, be spilled over a reel of film, or it even be dropped in a pail of water, it may be saved from damage if unrolled very quickly, not allowing the emulsion, which will be quickly softened, to touch anything. But the unrolling must be done very quickly or the emulsion will stick to the back of the film and pull off. This does not apply to colored or tinted film, though even these may sometimes be saved by very prompt action. The author once rescued a first-run film from destruction thus: He happened to be in the projection room after the show had closed for the night. In taking the last reel from the magazine it slipped from the projectionist's hands and landed in a pail of water, being practically submerged. He grabbed the reel, ran down stairs, handed the end to an usher, ran to the front end of the theatre, looped the film over a chairback, and ran back and forth until the whole film lay across the back of the seats. The emulsion became very soft in places, but next morning it was found that a total of less than five feet was damaged. The exchange men never knew of the occurrence until more than a month after, when they were told of it.

MOISTENING DRY FILM.—Traveling exhibitors often find that a film which has been a long time in use has become very dry and brittle. It may be remoistened and rendered pliable by unwinding into a large metal can, in the bottom of which water has been placed, with a wire screen over it to keep the film from contact therewith. Cover tightly, set in a moderately warm place until the film is soft and pliable. Watch closely, however, since if made too moist the emulsion will stick to the back of the film when it is rewound.

It is even possible to give a film a glycerine bath, as follows: In a shallow pan a few inches wide by 6 feet long place a solution of 30 parts of clear water to one part of glycerine. Make a drum of slats about six feet in diameter by about six feet long (for one thousand feet of film), and by revolving the drum draw the film very slowly through the liquid, winding on the drum with the emulsion side out. After the film is all on the drum, revolve it rapidly to throw off the surplus liquid, then continue to revolve the drum slowly until the film is dry. It should not be used for two or three days. Perform this operation in a room entirely free from dust, or you may seriously injure your film.

Due to lack of proper exchange inspection it is usually necessary to inspect the films at the theatre before they are run. To do this place the reel on rewinder, and rewind it very slowly, holding the edges between the thumb and forefinger with pressure enough to cup it slightly. By so doing you instantly detect all stiff or loose patches. Cut out the stiff ones and remake. Cement all loose patches and notch all split sprocket holes. If more than two sprocket holes are missing on one side—that is, in succession, of course—cut the film and make a splice. Remember, my friend, an ounce of prevention is worth a pound of cure. Managers, however, should not expect projectionists to inspect films for nothing. Such work is no part of his duty and should by all means be paid for, aside from the projectionist's regular salary.

EMULSION MAY BE REMOVED FROM FILM by soaking the film in warm water, to which ordinary washing soda has been added. Put in large double handful of soda to the bucket of water. Wash the film afterward in clean, warm water.

CLEANING FILM is a legitimate function of the film exchange. Film gradually accumulates more or less dirt and oil, all of which is highly injurious to the screen result. There are several cleaners on the market, designed for use in the projection room. They for the most part consist of an arrangement for holding pads of canton flannel or other material between which the film is pulled in the process of rewinding. These devices remove considerable dust and dirt, and at least some of the oil, but have not proven very popular, one reason being that there is always the possibility of damaging the film badly by some foreign substance sticking on the pads and scratching the emulsion in a straight line all the way through the film.

Alcohol will remove dirt and will not injure the emulsion, but it is likely to cause the film to curl very badly, hence it is not to be recommended for the cleaning of film.

The Research Laboratories of the Eastman Kodak Company is authority for the assertion that film may be cleaned with commercially pure tetrachloride without damage, provided the same be allowed to thoroughly evaporate before rewinding the film. To do this it is necessary to wind the film spirally on a drying drum, which must be about six feet in diameter by six or seven feet long for a thousand feet of film. The drum should be revolved until the film is thoroughly dry.

WARNING—If the film be cleaned by being pulled through a cloth moistened with tetrachloride, and be immediately rewound, sufficient of the fluid may, and probably will remain to attack and seriously injure the film image by bleaching it out.

Film may be cleaned with gasoline, benzine, toluene or zylene, but all these are inflammable.

The Eastman Company says: "The solvent tetrachlorethylene, made and sold by the Dow Chemical Company, Midland, Michigan, is non-inflammable and can be recommended for film cleaning. This substance does not attack the film, and is sufficiently non-volatile to remain for a short time before evaporating, and so has a chance to dissolve out the grease from the film before it is wiped off."

After using this solvent, however, the Eastman Company recommends that, as a precaution, the film be wound on a drying drum, as above described.

There is at least one firm in New York City which makes a business of cleaning film. Its process is quite thorough. The projectionist who wishes to use the cotton pad method can easily construct a device to hold two canton flannel pads, each about six inches long, together under some pressure, between which the film may be drawn in the process of rewinding. We do not especially recommend it, but it can be done. The pad should consist of at least four or five thicknesses of cloth—the more the better. It is even possible for the projectionist to remove considerable dirt and oil by pulling the film between absorbent cotton cloths held in his hands in the process of rewinding. As we said in the first place, however, the cleaning of film is a legitimate function of the exchange, and we recommend that the projectionist confine his efforts to careful handling of the film, to the end that no oil and as little dirt as possible be accumulated thereon while it is in his possession.

CLEANING PROJECTOR AFTER A FILM FIRE.—Burning film leaves a sticky, brown, gummy substance on metal. This may be easily dissolved and removed by washing the metal with ordinary peroxide of hydrogen, which may be had at any ten cent store, or at any drug store.

MEASURING FILM.—All standard professional projectors made in the United States, or, so far as we know, made anywhere in the Americas, pass exactly one foot of film to each turn of the crank shaft. The number of feet of film in a reel may therefore be measured merely by running it through one of these projectors and counting the number of turns of the crank shaft, which will be equal to the number of feet of film passing through the projector. Thus, if while running a given subject the crank shaft of the projector revolves 980 times, there are just 980 feet of film in that subject.

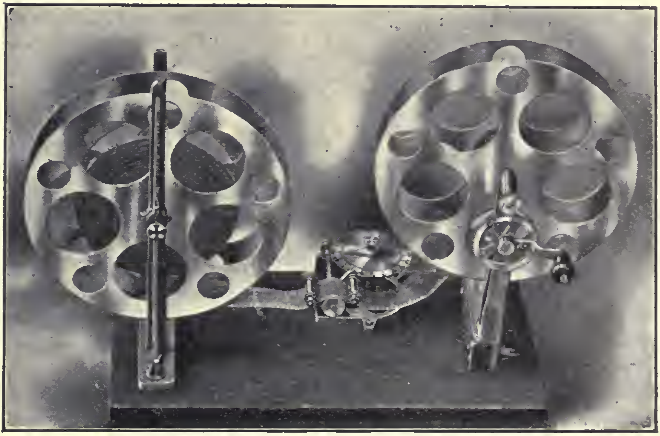


Figure 80-A.

There are also several film measuring devices on the market, which may be had of any dealer in motion picture supplies.

The way these devices operate is illustrated in Fig. 80-A. A very good makeshift film measurer may be had by disconnecting the intermittent of an old standard projector, using only the upper sprocket. One turn of the crank is then equal to one foot of film.

The Projection Room

THE projection room may properly be described as the heart of the motion picture theatre, since from it comes at least the major portion, and in some cases all of the entertainment provided by the theatre.

In the beginning of the industry the practice was to house the projector in a more or less flimsy enclosure, of the smallest possible dimensions, unventilated and located anywhere space could be found which had no possible value for any other purpose.

Of late, however, thanks at least in some measure to the work of the handbook and the projection department of Moving Picture World, exhibitors are beginning to understand something of the importance of a well constructed, commodious, well ventilated projection room; also that unless the same be so located that the projection lens will be central with the center of the screen, distortion of the picture and other evils will inevitably result; see Page 253.

LOCATION.—As has been explained under "Keystone Effect," Page 253, a location of the projection room which will produce a heavy angle of projection will not only result in distortion of the picture outline, but also of everything within the picture itself, and while it is possible to correct the outline distortion insofar as has to do with making the sides of the picture parallel, the distortion of objects in the picture itself can only be remedied by changing the angle of projection, which in practice means changing the location of the projection room.

In considering this matter the exhibitor and projectionist should understand that it is the angle which counts. This means that distance of lens from screen is a big factor in the matter, as is shown in Fig. 75, in which the height of center of projection lens above center of screen is the same in all cases. The 40-foot distance gives a 32 degree angle, the 80-foot distance only an 11 degree angle, while if the lens be moved back to 120 feet the angle would be only 7 degrees. This teaches us that if the projection distance be short, it is necessary, if the distortion is to be confined within a given permissible limit, that the height of the projection lens above the screen center be much less than if the projection distance be long.

The Society of Motion Picture Engineers has set its seal of approval on the following:

"PROJECTION ANGLE.—The maximum permissible angle of projection shall not exceed twelve degrees (12°) from a perpendicular to the screen surface."

While this is somewhat ambiguous, we may, we think, accept it as meaning that the maximum permissible angle of projection shall not exceed twelve (12) degrees from a horizontal line passing through the center of the screen, when the screen sets perpendicular.

An angle of 12 degrees amounts, roughly, to 2.55 inches to the foot. By "roughly" we mean that is close enough for practical purposes, though it may be a very small fraction of an inch more or less. From the foregoing we readily see that if we

Multiply the proposed projection distance, in feet, by 2.55 and divide the result thus obtained by 12, the final result will be the height, in feet, the lens may be above the screen center without exceeding a 12 degree angle of projection.

By subtracting the distance of the projection lens from the floor of the projection room from the result obtained by the application of the above rule we shall have the maximum permissible height of the projection room floor above the screen center. See remarks concerning 12 degree angle, Page 255.

In considering possible available projection room locations the angle of projection, and consequent distortion are, of course, of first importance, though this consideration is rivaled by another, namely,

LIMITS OF VIEW.—Select any familiar object, such as, for instance, a tree. Carefully observe it, in normal light, at a distance of 150 feet. You will of course see the tree as a whole quite plainly. You may even see most of its individual leaves, though in some places, unless your eyes are above the average, they will appear mostly as green masses of foliage, with the outline of individual leaves difficult to trace. Advance to a one hundred foot distance. You can now perhaps distinguish the outline of all the leaves, but the trunk most likely will only show as a light or dark object, without much detail of the bark being visible. Advance to seventy-five feet and see how much more clearly you are able to distinguish the individual leaves, and how the detail of the bark begins to show.

Precisely the same thing which was true of the tree is true of the picture on the screen as observed by the projectionist only, due to difficulty of looking through a comparatively small opening in the wall of an all too often well lighted room, the detail of the foliage of the actual tree will appear much more clearly than will the detail of the image of the same thing on a screen, distance being equal.

It therefore follows that distance of screen from projection room is of vital importance, since if the distance be too great the projectionist will not have a clear view of the detail of the picture, hence will be unable to judge of the fine sharpness of focus, and sharpness of focus is of vital importance, since it has intimately to do with eye strain.

Many exhibitors permit the establishing of an abnormally long projection distance, and then try to compensate for the poor view the projectionist has of his screen by providing an opera glass. This latter is, of course, an excellent thing to do, even with a short projection distance, because there are times when the projectionist will wish to observe the screen very closely, but to attempt to compensate for a too-long projection distance thus is in the nature of a makeshitt, and one which is only partly successful, because a projectionist just simply will not use a glass as often as would be necessary for the best possible results.

It is just plain common sense that the picture should be kept in as sharp focus or definition as possible.

It is also just plain common sense that if the projection room is so far from the screen that the projectionist cannot see the finer details of his picture clearly and sharply, the picture will not be in constant sharp focus, or at least not in the sharpest possible focus.

Oh yes, we grant you the projectionist **can** use an opera glass, but, as we before said, **he won't,** at least not with sufficient regularity to insure 100 per cent. sharpness.

It therefore follows that for best results (and any other than best results will inevitably react to the injury of box office receipts) the projection room must not be placed too far from the screen. But to determine the maximum permissible limit of distance is a difficult matter. Perhaps it may be best disposed of by saying that beyond seventy-five feet the view of the picture from the projection room cannot possibly be what it should and must be for best results, hence the result will inevitably suffer at least to some extent, insofar as concerns sharpness of focus. Of course as the distance increases the view of the screen from the projection room will become less distinct.

But this element interlocks with another to the extent that any distance sufficiently short to require a projection lens of very short focal length—say less than 4 inch E-F, is highly objectionable, because very short focal length lenses do not give sharpness of definition all over the field.

The whole subject of projection room location is full of complications, but it may be set down as fact that, except in those few cases where extraordinary sacrifice would have to be made to do it, it will be a paying proposition to so locate the projection room that the picture height will not be increased by more than 5 per cent. through distortion due to angle of projection, and the projection distance (throw) such that not less than a 4-inch E-F projection lens will be required and as little more than seventy-five feet from lens to screen as can be accomplished.

FRONT OF BALCONY LOCATION.—The location which promises best results in large theatres is in the body of the balcony. This location is a recognized possibility by some architects now, and will, we have faith to believe, become increasingly popular when theatres are planned in which there is to be a balcony, and in which other available locations would either give a too steep projection pitch, or else a too great distance of projection.

In Fig. 81 we see the diagrammatic representation of the possibility of such a location. The possible objections are: (a) Cost of installation. (b) That the balcony will sag somewhat under stress of load. (c) That proper ventilation will be difficult. (d) That in case of fire there would be danger of panic by reason of smoke coming out in the midst of the audience.

These objections are, except for the first named, capable of being reduced to practically nothing at all. The balcony will settle somewhat, yes, but it is a simple matter to construct a compensating projector table which will take care of this and keep the picture automatically centered on the screen. See Fig. 81 A. Such a room may be ventilated as much as may be desired. It is merely a matter of cost of necessary vent ducts, and their installation; also ducts may be easily provided which will carry away every particle of

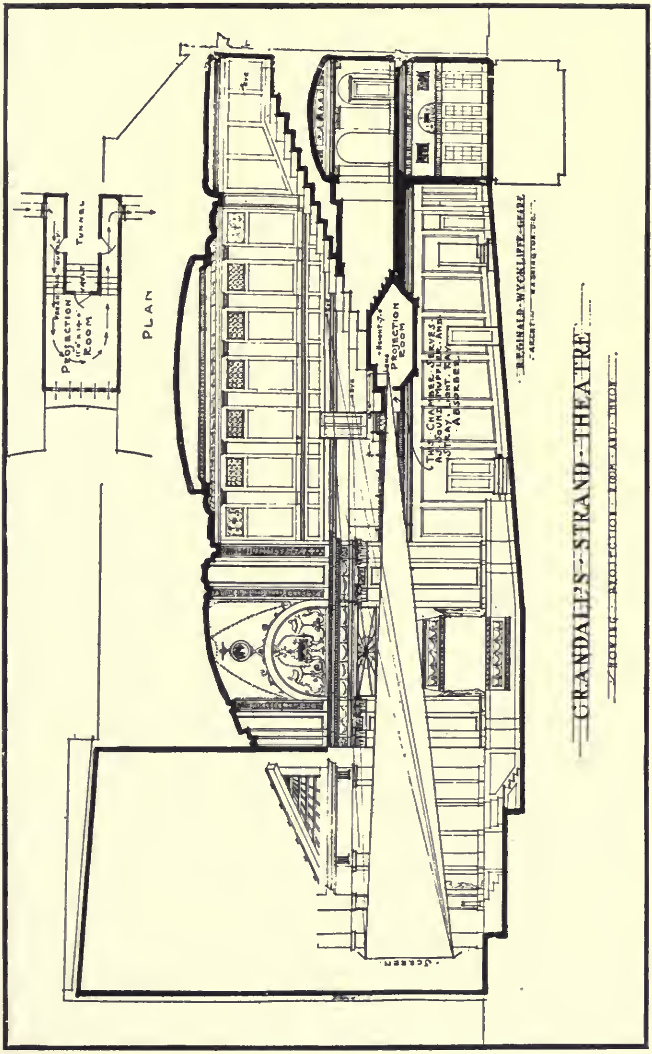

CRANDALL'S · STRAND · THEATRE
REGINALD WYCKLIFFE GEARE
PLAN
PROJECTION ROOM
TUNNEL
THIS CHAMBER SERVES AS SOUND MUFFLER AND STRAY LIGHT RAY ABSORBER
SCREEN

Figure 81.

smoke and gas in case of fire, so that although a portion of the audience may, and probably will, be seated literally within eighteen inches of the ceiling of the room, they will not be aware of anything more than a stoppage of the show should a fire occur. It is a simple problem to make such a room practically entirely sound proof. In fact, there is no valid objection to such a projection room location, except the matter of installation cost. It is a lamentable fact that both architects and exhibitors, with some exceptions, seem imbued with the idea that projection room location is of no particular importance. This error is tremendously harmful to the industry, because it makes for inferior results on the screen, and inferior results on the screen make for a less pleasing general screen result, with consequent lessened patronage.

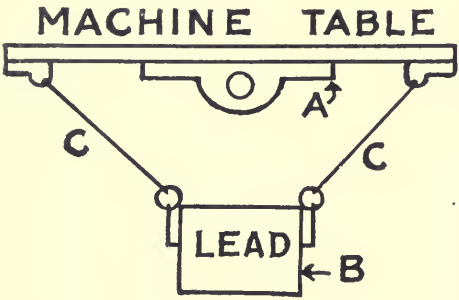


Figure 81 A.

THE MAIN FLOOR LOCATION.—The location of the projection room on the main floor of the auditorium offers no insuperable, or even largely objectionable difficulties, as has been amply proven in the west, where many high-class theatres have projection rooms thus installed. It is very largely a matter of occupying space which might otherwise be devoted to high-priced seats.

The point the exhibitor who objects to the main floor location overlooks, is that with a main floor projection room location he gets maximum possibility for screen results, hence greater drawing power at his box office.

Take a theatre seating two thousand, for example. Assume it to give three shows a day. It then has 2,000x3=6,000 seats to sell each day. Suppose the projection room occupies space in which 30 seats might be placed, and that those seats, if filled, will sell for fifty cents each, or forty-five dollars a day. Mark you well the IF FILLED. How many theatres do sell their entire seating capacity for three shows? Very few, if any, except in the case of attractions which have within themselves an extraordinary drawing power, hence we may reduce the loss by at least one-third, making it thirty dollars. But even that is a very serious matter, unless compensated for.

And right there, Mr. Exhibitor, we ask you to think very carefully. You will, we believe, agree that a clear cut, undistorted picture will be more pleasing to your audiences than will the heavily distorted picture which is not in the sharpest possible focus (two faults which are the invariable accompaniment of the long projection distance and the top of the balcony projection room location) and that the more pleasing picture, or more pleasing general screen result must and will operate to the benefit of the box office. Is it not therefore reasonable to suppose that by the sacrifice of some of your high-priced orchestra seats (which will only be really sacrificed when you have a capacity house) you will sell a greater number of seats at times when your theatre is not normally full. In other words, while the perfect screen result cannot increase the business of your capacity shows, it can and will increase the business at the shows which do not do a capacity business.

The fact is that the perfect screen result upon a main floor location will sell more than enough additional seats to make up for those lost, while the front-of-balcony location will sell the additional seats without entailing any sacrifice in seating capacity.

One objection advanced as against the main floor location is that it necessarily restricts the size of the projection room. True, but immediately below usually is plenty of available room in the basement, in which re-winding can be done, repairs made and where motor generators, etc., can be located, the room below being connected with the projection room by an incline or a stair.

The main floor location is of course usually only available in theatres planned to accommodate it, because the methods for disposing of smoke and gas must be taken care of in the structure of the house. Otherwise it would be difficult, if not impossible, to install the necessary ducts without sadly marring the beauty of the theatre.

Summed up, the rear of the auditorium at the top of the balcony is usually a miserable projection room location, from the viewpoint of excellence in screen results. It generally gives projection pitch far in excess of that permissible in good practice. It usually gives a too-long projection distance, which operates to produce heavy waste of light in the projector optical system, as well as to make impractical the maintenance of maximum sharpness in focus of the picture. The only advantages of such a location are ease of ventilation, ease of taking care of smoke in case of fire, ease of sound-proofing and cheapness of installation. In other words it barters high-class screen results for cheapness of installation and ease of operation.

The front-of-balcony location costs more to install, but should give an almost ideal projection distance. If properly installed its fire dangers are purely imaginary, its thorough ventilation entirely practical and it may be depended upon to provide a projection angle well within the permissible limit. Special projector tables, Fig. 81 A, will automatically take care of displacement of picture through sag of balcony under load.

The main floor location is entirely practical, from any and every viewpoint. Its only legitimate objection is that it is more costly of installation, and reduces seating capacity, though in the long run it may be depended upon to produce quite sufficient revenue to more than compensate for the seating space it occupies.

The following may be considered as the essentials of a first-class up-to-date projection room:

(A) It must be so located that a point central between the two projector lens ports will be exactly centered with the center of the screen sidewise, and its height above the center of the screen must be such that the distortion of the picture will in no cases exceed 5 per cent. of its normal or undistorted height.

(B) The minimum distance of the projectors from the screen should be such as will call for the use of a projection lens of not less than 4-inch E-F. Anything less than this focal length will make it either very difficult, or impossible to secure sharp definition all over the screen without reducing the working opening of the projection lens, which means loss of light. On the other hand the distance from the lens to the screen may be as much as 250, or even 300 feet, though we would advise against such an attempt and very strongly recommend that the projection distance be kept within a maximum of 75 or at most 100 feet, since long projection distance means loss of light in the optical system and more or less tendency to lack of sharpness in the picture through inability of the projectionist to see it clearly.

(C) The projection room must be absolutely fireproof, which includes not only the construction of the room itself, but the shuttering of its ports and the providing of sufficient vent pipe area to carry away all the smoke and fumes of burning film.

(D) The projection room must have a very solid foundation, since the least vibration in the floor will inevitably produce vibration of the picture upon the screen.

(E) The projection room must be as nearly as possible soundproof, to the end that the noise of the projectors, the rewinder, and the motor generator set or transformer, as well as the conversation sometimes necessary between the projectionist and his assistant be not audible in the auditorium.

(F) The lighting of the projection room must be such that in case of trouble the room may be instantly and brilliantly illuminated, to the end that repairs proceed with maximum speed. The lighting must, however, be so arranged that the projectionist may either extinguish all lights, or else greatly dim the illumination by means of a switch located within convenient reach from his position beside either one of the projectors.

(G) The color of the walls and ceiling is important. The optically correct color for the interior of projection rooms is a non-gloss dead black, but where this is objected to a very dark bronze green or a dark brown or chocolate may be substituted with satisfactory results. The important thing is that the best possible view of the screen is had when the projection room is dark, and the darker it is the better will be the view of the screen.

(H) The projection room should be reasonably easy of access, preferably not opening directly into the auditorium. It should be reached by a stairway rather than by a ladder. If it does open directly into the auditorium, then the stairway or ladder should be surrounded by some sort of partition so that in case of fire the projectionist may leave the room without allowing a cloud of smoke to escape into the auditorium to terrify the audience.

(I) The projection room should be large enough for reasonable comfort, allowing not less than two feet in the clear behind the projectors, after they have been set far enough back from the front wall, so that the projectionist may pass between the lens and the wall, with not less than six feet in width for a single projector and 3 feet additional for each additional projector, stereopticon or spot light.

The ceiling should be as high as practicable—the higher the better, within reason of course. In any event 78 inches from floor to ceiling should be the absolute minimum.

(J) All openings must be equipped with fireproof shutters or doors which will close quickly and automatically in case of fire, except the vent flue, which must be unobstructed if there is a fan; if of the open type then it must have a damper **weighted to remain normally open,** as will be hereinafter explained.

(K) There must be a vent flue or flues leading preferably as nearly as possible directly to the open air above the roof.

(L) All wires must be in conduit, and the conduit system must be thoroughly grounded. Fuses and switches should be in metal cabinets or cabinets built into the wall and covered with a metal facing, except in cases where a regular switchboard is employed. Conduits should, where possible, be built into the walls, and conduits leading to the projectors should be carried under the floor to a point immediately beneath the lamp house of each projector.

(M) The projection room must contain nothing except those things necessary to the work of proiection.

(N) There should be proper tool racks, and a separate closet for each projectionist's clothes and tools; also either in the projection room or immediately adjacent thereto should be a substantial work bench equipped with a substantial metal vise and a small anvil, which two last named may be combined in one.

The switches and apparatus should be so arranged that they will be easy of access to the projectionist, both for manipulation and for repair. Making things unhandy for the projectionist is one of the most expensive things we know of.

(P) It should contain only the most up-to-date apparatus, which same must be kept in the best possible condition.

(Q) The projection room must have observation ports of such size that the projectionist may have a clear, unobstructed view of the entire screen, either when seated or standing in working position beside his projector.

(R) The exterior of the room should be as inconspicuous as possible; that is to say, it should be decorated to harmonize with the rest of the theatre if it projects into or occupies a position in the main auditorium.

(S) If good results are to be expected and those results are to be had with a maximum of efficiency, the projection room must be placed in charge of a thoroughly competent reliable staff of projectionists, who are possessed of both practical and technical knowledge of the art of projection, and who are able to supplement their knowledge by a good fund of horse sense. No applications for position as projectionist should be considered unless the applicant can show that he has served at least one year's bonafide apprenticeship in a projection room.

(T) Either in the projection room or immediately adjacent thereto should be a wash bowl with running water. In handling carbons and in oiling the projectionist gets more or less grime on his hands, and unless this be washed off some of it will adhere to the films, to their damage. It is also imperatively necessary that toilet facilities be provided.

(U) There should be a telephone to the manager's office and, under some conditions, to the orchestra pit and stage. This is essential to modern practice. It should be a house phone only, not connecting with outside telephones, though an arrangement may well be made for such connection, but through the manager's office only.

(V) Proper tanks must be provided for storage of films when not in use. These tanks should be such as will (a) provide a separate fireproof compartment for each reel. (b) Each compartment should close automatically by gravity. (c) Top of tank should be so shaped that it will not serve as a shelf for reels of film or other things. (d) Place should be provided for moisture-containing sponge.

(W) In case the houselights are not handled from the projection room, there should always be a switch therein by means of which the projectionist will be enabled to light the auditorium instantly in case of serious trouble.

The foregoing constitutes what might be termed the fundamental essentials of projection room construction and equipment, but in addition a detailed explanation of the various things is necessary.

PROJECTION ROOM DOOR.—The door of the projection room must not be less than two feet wide by six feet in height. It must, of course, be built of fireproof material. Three-eighths inch asbestos mill board on both sides of a steel frame is perhaps best. The door may be either hung on hinges, in which case it must always open outward and be held normally closed by a substantial spring, or, very much better, it may be a sliding door so arranged that it will be normally held shut by gravity.

This latter idea is illustrated in Fig. 82, in which is a door constructed as above set forth, hung on an inclined track. Such a door is easy of manipulation and not expensive in first cost. It will always remain closed unless it be deliberately fastened open.

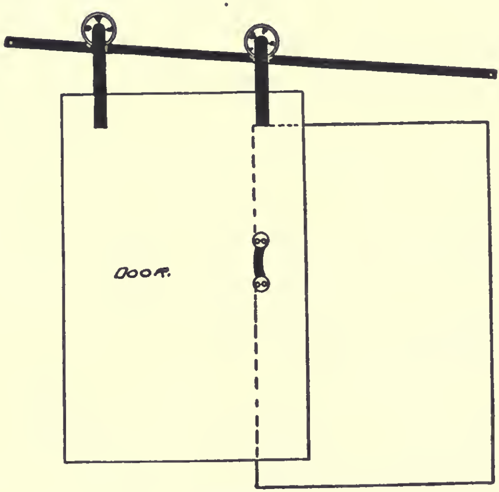


Figure 82.

THE FLOOR.—The foundation for the projection room floor will, of course, vary with the circumstances of the installation, but it must be such as will hold a floor absolutely without movement or vibration of any kind, because if the projection room floor moves or vibrates, then the projector itself will move and vibrate, which means that the picture on the screen will move or vibrate, and this latter may be a very serious matter, indeed.

Suppose the projection room floor to vibrate evenly all over precisely 1/16 of an inch. This would mean that the whole picture would move up and down on the screen exactly that much, which would, if the vibration was only occasional, probably be imperceptible, but would, if the vibration be rapid, have the effect of injuring the definition of the picture. But suppose the floor vibrate in such manner that the condenser be moved up and down 1/64th of an inch more than the projection lens. This would set up a condition such as is shown in Fig. 83 and the effect on the picture on the screen would increase in proportion as the distance from the lens to the screen increases. In Fig. 83 A is the light source and B the projection lens. If A be moved down 1/64th of an inch, B remaining stationary you will readily see that the movement of the light beam at a point say 100 feet away will be considerable. The dotted line illustrates the result.

Modern practice is to provide a solid foundation upon which is placed not less than six inches of a rich concrete, well tamped down. On this is placed a top dressing of

Figure 83.

cement from .5 of an inch to one inch thick, essentially of the same composition as is used for side walks.

WARNING.—An enormous amount of damage is done both to machinery and to film by improper mixing of the top dressing of projection room floors, or by the use of poor cements. If the top dressing be not properly mixed, or if it be of poor material, it will constantly wear off, and the resultant dust is a very fine abrasive powder. It gets into the bearings of projectors, motors and generators and wears them out very rapidly. It gets on the film and is one of the greatest rain producers known. We have seen many projection rooms in which an improper top floor dressing was shortening the life of the machinery enormously, as well as doing immense damage to the films used therein.

FLOOR DRESSING.—Where such a floor exists it is possible to apply a preparation which will stop the trouble, or the floor may be painted with a good floor paint. Exhibitors will do well to remember that a projection room cement floor which slowly disintegrates into dust is about as great a damage producer as they can have in their theatre, and one great trouble with this particular thing is that the damage done is so nearly imperceptible that neither the exhibitor or the projectionist realizes how serious it really is.

One of the best possible coverings for a projection room floor is a heavy matting made of a cork composition, such as battleship linoleum, but the plain cement finish will not produce trouble if it is made from a proper mixture of good cement. A floor built of concrete as described, finished with a proper top dressing of cement, will to all intents and purposes be just one solid block of stone, and you will have no vibration at all, because a thing of that kind is altogether too heavy to vibrate.

WALL CONSTRUCTION.—Where there is no objection to weight, cement or brick is very good for wall construction. Either is, of course, thoroughly fireproof. Hollow tile has distinct advantages, however. If properly and carefully laid in rich mortar, well tempered with cement, it is just as good for the purpose, viewed merely as a wall, as cement or brick, and is much more nearly soundproof than either; also it does not act as a heat reservoir as does brick and cement. Where hollow tile is used it should be well plastered on both sides, either with one of the hard-setting patent plasters, or with a strong lime mortar strongly tempered with cement.

When either of the three before named forms of construction are used the ceiling may be of the same material, carried in the usual way, between I beams.

It is not the purpose of this work to enter into details of construction. That is the business of the architect. Our intent is only to point out those things which practice has proven to be satisfactory.

BUILDING IN CONDUIT.—All projection room circuits must be in conduit, and where cement construction is used it is much better that the conduit be placed in position as the walls are built, so that it will be imbedded in the walls themselves. Where brick construction is used it is possible to leave grooves in the wall, so that the conduit can be placed therein and afterward imbedded in plaster. The bricklayer mason may charge extra on account of the trouble involved in doing this, but it nevertheless is practical and worth while, because the conduit is then not only held firmly in place, but becomes a part of the wall itself.

PORTS.—Each projector must be provided with a lens port and one observation port. Each stereopticon must have one observation and one lens port, but a spot light need only be provided with one large port. Of course if the projector be provided with a stereopticon attachment, then a separate port must be provided for slide projection.

LOCATING PORTS.—The way architects locate lens and observation ports usually results in handicapping projection forever after. The average architects, if we are to judge by what they do, have little, if any, comprehension of the importance of properly located ports of proper size. They locate a lens port somewhere near right, and an observation port which, four times out of five, is nothing short of an outrage, and which makes high class screen results highly improbable, if not entirely impossible. We strongly recommend the following procedure in planning the projection room front wall.

Lay out the openings as per Fig. 84, in which A and B are

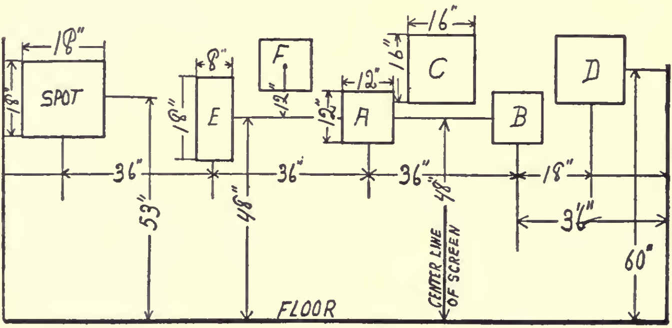


Figure 84.

the projector lens ports, C and D the projector observation ports, E and F respectively the stereopticon lens and observation ports, the latter of which may be made any size desired not less than ten inches square.

It will be noted that the projector lens ports are indicated as twelve inches square. This is for the reasons given further along. If it is not desired to follow the procedure we shall indicate for filling in the lens ports, then their size may be reduced accordingly, but the filling-in plan is most satisfactory in the end.

The distance between ports A and B is the absolute minimum consistent with good work and decent conditions. It should never be less, and should never be more where the distance of projection and picture size be such that a projection lens of less than 6-inch E-F is required. When the projection lens E-F exceeds 6 inches, the distance between ports A and B may be increased gradually as the E-F of required lenses increases, until with an 8-inch E-F lens it is possible to have as much as five feet between projector lens centers, though four feet gives ample room and should not be exceeded.

The distance between stereopticon and spot may be reduced, if necessary, as may also the distance between the stereopticon and left hand projector, though we do not advise this latter if it can in any way be avoided, as it sets up a bad condition.

Ports A and B must, of course, be spaced equi-distant from the center line of the screen.

The distance from port B to the wall also is intended as an absolute minimum. It is, in fact, too little. When it is possible, at least, another foot should be allowed.

CAUTION.—The distance of the center of projector observation ports C and D above the floor is shown as 60 inches, which is about right, everything considered, for level projection and the average man, but if there is considerable pitch in the projection the ports will be too high. It will be found very satisfactory to **make the projector observation ports 16 inches wide, with their centers 60 inches from the floor, and then lower them four and one-quarter (4.25) inches for every five degrees pitch in the projection.**

Thus: If there be a 20 degree pitch in projection, then the centers of the sixteen-inch-square observation ports should be (4.25x4=17) 60—17=43 inches from the floor. If there is considerable pitch in projection it will also be necessary to lower the lens ports.

It will be observed that ports A and B are 16 inches square, and that port E is 18 inches high by 8 inches wide, which is, of course, far in excess of the actual requirement. The center of the lens of the average projector is about 48 inches from the floor when the projector is level. The idea in making the lens port opening of the wall 12 inches square is that after the projectors are placed in position and the light properly centered on the screen the opening may be filled in as per Fig. 85, in which A is an asbestos mill board ⅜ inch thick set into the opening and flush with the outside edge of the wall. This is only placed in the port after projector has been set in place and the light has been centered on the screen. After placing board A in position, turn on the light, which will form a spot on board A. With a pencil, mark around the outer edge of the spot and then cut a hole in the board just a bit larger. Next a similar board is placed as per C and the hole marked in the same way and cut out, after which the two boards are placed in position and bolted together, a wood spacer being used as shown. We thus have a lens port exactly the size of the requirements of the local condition. F-F are bolts holding the whole thing together. This port filling is effective and its cost is small. Stereopticon lens port E should be filled in in the same way. Flanges of asbestos mill board may be added, as per dotted lines, if desired.

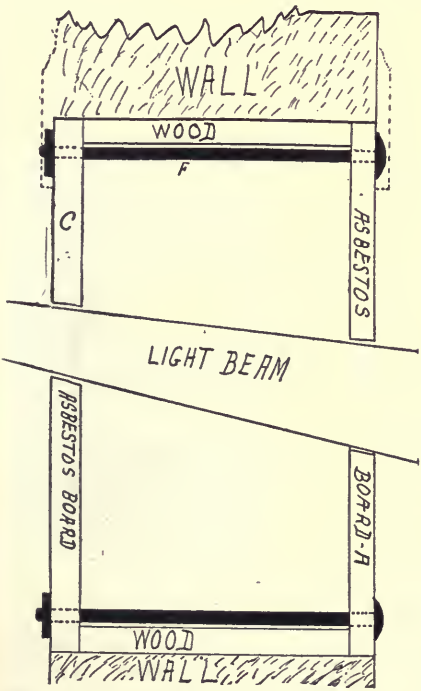


Figure 85.

C and D, Fig. 84, are, you will observe, 16 x 16 inches in dimension, with their horizontal centers located 60 inches from the floor line, and the vertical center 18 inches from the centers of the lens ports. **Observation ports should, under no circumstances, be less than 12 inches wide, and 16 is much better.** Anything less than 12 inches compels the projectionist to put his eyes right up against the port in order to get a clear view of the screen. The average layman, or even the average projectionist, does not realize how true this is, or what an effect the narrow observation port has in injury to the definition of the picture on the screen, by reason of the fact that the projectionist just simply cannot see clearly through a small hole. Where a local law limits the size of observation ports it is entirely practical to cover a large port with a sliding shutter in which an opening 12 inches wide by 6 or 8 inches high has been cut. This sliding shutter must be so arranged that the bottom of the opening in it may come down to the bottom, and the top of the opening raise to the top of the hole in the wall. It should be arranged with a counterweight so that the projectionist may move the opening up or down to the most convenient position. The plan is illustrated in Fig. 86.

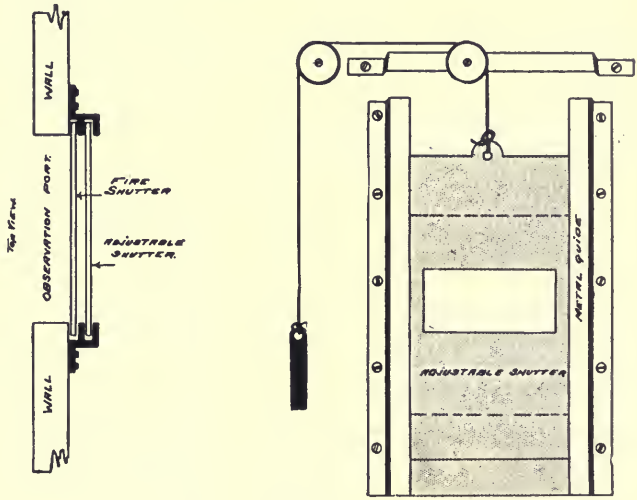


Figure 86.

The important point in making an observation port of generous size is that unless the projectionist watches his screen constantly there will be faults of various kinds in the projection, and most certainly there will be little if any of that regulation of the speed of projection which is so necessary to high class work. Moreover, unless the port be of ample size, the definition of the picture on the screen will not be as sharp as it should be, which means added and unnecessary eye strain to the patrons of the theatre.

GLASS OVER PORTS.—It is entirely practical to place glass over the observation ports, provided the right kind of glass be used, and further provided the glass be properly installed and KEPT CLEAN. An old photographic plate with the emulsion cleaned off is the best glass to use, though any high grade glass will do. See Page 290 for directions for removing photographic emulsion.

Where glass is placed in an observation port it should be set at an angle from the vertical, which will serve to kill the reflection from its polished surface. It must either be made easily removable, or be hung on hinges so that it may be readily cleaned on its outer surface. If the glass be set at an angle, and the port be surrounded by a shadow box painted black on the inside, as per Fig. 87, the reflection from the glass will be entirely killed and the view of the screen made very much better.

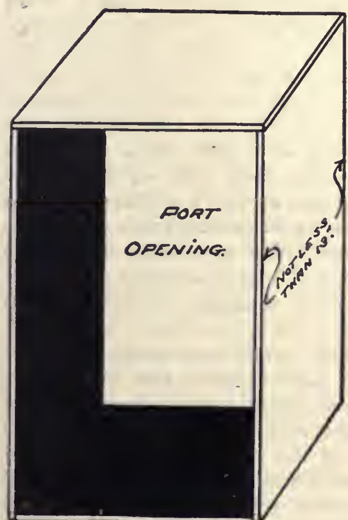


Figure 87.

In one of the San Diego, California theatres the author saw what seemed to be the ideal observation port. It was located between the projectors, was about 30 inches square and was covered with plate glass, in the center of which a circle 10 inches in diameter had been cut out. With such a port it seems possible to have the projection room at all times fairly well lighted, provided the lights be properly placed, and at the same time to have a most excellent view of the screen.

GLASS IN LENS PORTS.—Many projectionists now use glass in both the lens and observation ports. The glass over the lens port need not necessarily do any harm, insofar as the definition of the picture be concerned, but it does cause considerable loss through reflection, particularly if it is not kept scrupulously clean. If the lens port be reduced to the actual requirement of the beam there is seldom any necessity for covering it with glass, since the opening will be very small. Our advice is to reduce the lens ports to the actual requirement, as per Page 309, and omit the glass.

SMALL PORTS AND THE LAW.—In some states the size of projection room ports is limited by law, and the limitation is such that high class projection is prevented, since it is impossible for the projectionist to secure a really good view of his screen, even when right up against the port.

WE CHALLENGE ALL SUCH LIMITATIONS AS SERVING ABSOLUTELY NO GOOD PURPOSE, EITHER IN SAFETY OR ANYTHING ELSE.

In case of fire, smoke will make its way through a small opening practically just as quickly as it will through a large one, and if the audience once gets sight of smoke the damage is done and the panic started, if there is going to be one. The escape of smoke from the projection room is, however, supposed to be prevented by the fire shutters and **there will not be the difference of 1/25th of a second in the time required for a shutter to drop over an opening 16 inches square and the time required for a shutter to drop over an opening 4 inches wide by 12 inches high.**

Then, too, the larger shutter being much heavier is less likely to stick than the small one, which actually places the balance on the side of the large opening, insofar as concerns safety.

If law makers and inspectors would pay more attention to the proper construction of port shutters and the proper placing of the fuses in the lines which support them, leaving the size of the opening to take care of itself, the result, insofar as concerns the safety of the public, would be greatly improved, and the enormous handicap against projection caused by small observation ports would be removed, to the great benefit of results on the screen, the lessening of eye strain for the spectators and the increasing of the enjoyment of the show by the public.

SPOT LIGHT PORT.—The spot light port, if one there be, should be located with its center about 4 feet 6 inches above the floor line. The opening should be 16 to 18 inches in diameter, square or round, as preferred.

PORT FIRE SHUTTERS.—Every observation port, lens port and spot light port should be provided with a fire shutter. The best material from which to make these shutters is asbestos mill board, ⅜ of an inch thick. Some authorities are satisfied with 16-gauge sheet metal, which will serve very well, though it is not, we believe, all things considered, as satisfactory for the purpose as asbestos board.

The proper installation of port shutters, together with an adequate vent flue and thoroughly fireproof walls offer not only adequate protection from fire damage to anything outside the projection room, but also against the probability of alarm on the part of the spectators should a fire occur in the projection room. This latter desirable end will, however, not be accomplished unless the port shutters be so hung that they will close the instant fire starts. **This is of absolutely supreme importance.** It is very, very seldom, if ever, that a projection room fire does any injury to anything outside the projection room itself. The damage is practically always caused by the panic which almost invariably follows an alarm of fire where an audience is gathered. Now that all projection rooms are fireproof, it may be stated as a fact that,

Barring panic, there is absolutely no danger of any kind whatsoever to an audience or to any individual thereof through a projection room fire.

A splendid result would be accomplished if all theatres were required to run a slide reading something like this, before each performance, for a period of six months:

"The projection room of this theatre is thoroughly fireproof. In the improbable event of a film fire there is absolutely no danger to the audience, as in no possible event could anything more than possibly some smoke reach the auditorium."

The foregoing might possibly be improved as to its wording, and is intended only as a suggestion.

It is a deplorable fact, however, that a large proportion of the average audience becomes raving maniacs the instant there is an alarm of fire. Given a glimpse of fire or smoke you may depend upon them to go stark raving mad, pile up in a heap and kill each other either through trampling or suffocation.

We desire to strongly impress upon architects and exhibitors and public officials the fact that it is entirely practical and feasible to prevent the audience from having any glimpse of either fire or smoke when a film fire occurs. In order to accomplish this, however, port shutters must be so fused that they will automatically close every opening in the projection room within three or four seconds of the time a fire starts.

The port fire shutters should be so arranged that they may all be dropped by the projectionist with one motion, but depending upon him is by no means a safe thing, since the projectionist is but human. When the film catches fire he is likely to become more or less excited, and one never can tell what an excited man will do, or what he won't do. We therefore emphasize the fact that.

Port shutters should be so fused that they will automatically close all the ports within three or four seconds of the starting of a fire at either projector, at the rewind table or the film storage can.

This latter proposition hinges entirely upon the kind and location of the fuse links. All shutters should be held by

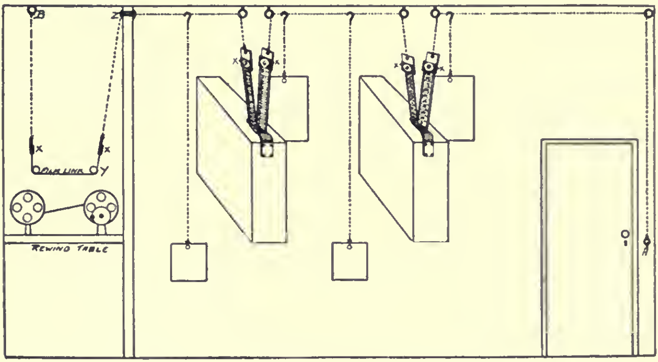


Figure 88.

one master cord, and that master cord should contain fuse links, preferably of film. But whether the fuse links be of film, or the regulation metal fuses should NOT be located 4 or 5 feet from the probable sources of fire, but as closely as possible to (a) each projector upper magazine, (b) the film storage magazine and (c) the rewind table. If metal fuse links are used they should be of the 160 degree fuse metal, or the most sensitive fuse metal obtainable. One method of using film links is shown in Fig. 88.

There are several patent port shutter supporting and releasing devices made, and they are all of them good, provided the fuse link be located where it will do real service.

There is one plan, however, the invention of F. E. Cawley, Mason City, Iowa, which is of such general excellence that it deserves description. Its chief point is illustrated in Fig. 89, in which A is a round shaft hung in suitable bearings attached to front wall at suitable height. To it is attached lever B, as shown. In shaft A holes about ⅛ inch in diameter are drilled, passing clear through. These holes are indicated at G-G-G. There must be one over the center of each port opening. To each port shutter a suitable cord or wire is attached, at the other end of which is an ordinary cotter pin about an inch long. The same purpose would be

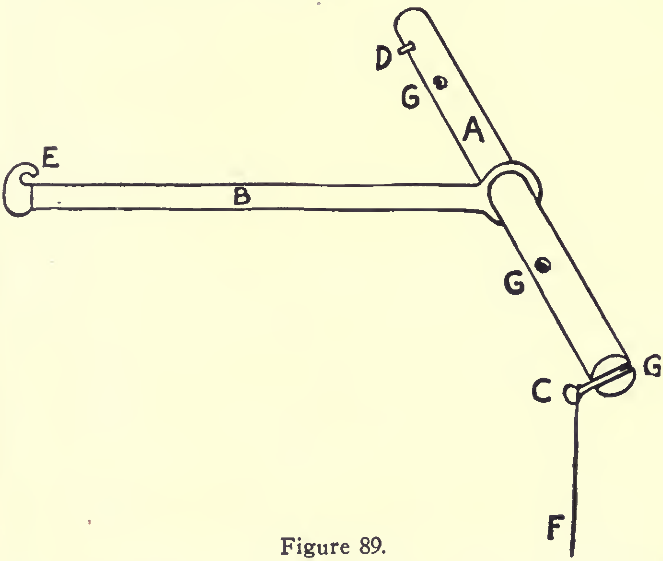


Figure 89.

served by a pin, as at D, and a small harness ring. The action is as follows:

Lever B is raised to horizontal position, which must also bring holes G-G-G to horizontal position, and a master cord is attached to the hook at its end. This cord may be carried down to proper position at each projector, also down over the film storage tank and the rewinder table, being fused with link or metal fuses, **or both**, at proper places. It terminates in a metal ring designed to be hooked over a headless spike just inside the projection room door.

It will readily be seen that when the master cord is released, either by a fuse or by removing the ring from the spike, lever B will fall, and in so doing will rotate rod A one-quarter of a turn, so that holes G-G-G will be vertical, whereupon pins C will be released (they must fit very loosely in the hole) and the shutters will drop of their own weight.

The superiority of this plan is that it combines the great advantage of fusing at as many places as may be desired (the master cord really need never be disturbed, except in case of emergency, as a fire) and the ability to raise or lower each shutter entirely independently of every other shutter. Also it can easily be made by any competent blacksmith or machinist. The scheme has our hearty commendation.

AUTHORITIES IN ERROR.—As a general proposition authorities permit or even demand the locating of port shutter fuses near the ceiling. Their theory is that since heat rises the air at or near the ceiling will become heated very quickly. This is true, but where a panic may hinge on a matter of two or three seconds the plan is a very bad one. It is all right to locate fuses near the ceiling, but there must be other fuses near the probable source of fire. Fuses are cheap, and it won't cost much to use a dozen of them. On the other hand a fire panic may be very expensive in human life.

Let it be clearly understood that in the foregoing it is also presumed that a proper arrangement will be made whereby the projectionist may himself drop the port shutters, which should be absolutely the first thing he does, after dropping the douser or pulling the switch, when a fire starts, since **the safety or the audience is paramount to everything else.**

PADDING THE FIRE SHUTTERS.—When the port shutters drop, their bottom edge should rest either on rubber or felt. The most important purpose of the port shutter is to prevent the audience from even knowing there is a fire in the projection room. If from four to six heavy shutters drop with a crash, the effect is to instantly draw the attention of the entire audience directly to the projection room. The pad is designed to avoid this very thing. Of course in theory the shutters should be dropped gently, but when a fire occurs and the shutters drop automatically through the burning of a fuse, gravity won't act very gently, and even if the projectionist drops them he has not, under the circumstances, time to be very gentle.

Fig. 90 indicates a proper method of padding the shutters to prevent a noise when they drop.

VENTILATION of the projection room serves three purposes, viz.: to provide fresh air to the men working therein, to keep down the temperature and **to provide means for carrying off all the smoke and gases generated in case of film fire.**

The vent flue should, wherever possible, pass directly from the projection room ceiling through the roof to the open air, its top being not less than 3 feet above the roof and protected by a suitable hood to keep the rain from beating in. The open vent flue is neither safe nor desirable, because of the fact that under some conditions it is

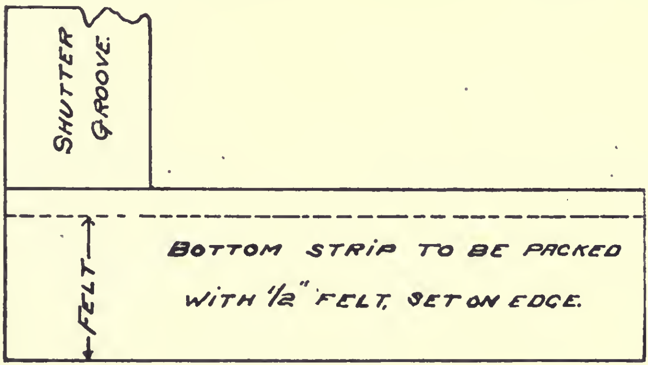


Figure 90.

quite possible, and even probable, that the draft through an open vent would be downward instead of upward. This is especially true in some locations when the wind is in certain directions, as any housewife who has had experience with a smoking chimney can testify.

The laws of some cities or states stipulate a certain size vent flue for a certain size projection room, and another size flue for a different size projection room. This might be correct if only the purposes of ventilation were to be served, but one of the important offices of the vent flue is to prevent panic by carrying off all the smoke and gases, and film burning in a small room makes just as much smoke and gas as it does in a large one, hence a small room should have just as big a flue as a large one.

If the vent flue or pipe be of the open type it should have an area of not less than 288 square inches, regardless of the size of the room.

Where a vent flue depending upon a fan for its action is used, the fan should not be less than 24 inches in diameter. Where fans are used it is an exceedingly good practice to install two vent pipes and two fans instead of one, so that in case one of the fans gets out of order there will still be the second one to fall back on. This may seem like rather an expensive precaution, but since the pipe containing the additional fan may join the pipe of the other fan, the added expense will be largely that of the second fan, and where the safety of the audience is concerned expense should not be considered.

It is essential that the vent flue, if made of metal, be thoroughly and completely insulated from any inflammable substance throughout its entire length, since it is likely to get very hot if there is a serious fire in the projection room.

With proper means provided for the egress of smoke and gas, when a film fire occurs, the projection room with fireproof walls will be nothing more nor less than a huge stove, the draft being inward around the cracks of the port shutters and door, and outward through the vent flue; so that no smoke or gas will in any event show in the auditorium. Hence the audience will never know there is a fire in progress, even though their attention be attracted directly to the room by the stoppage of the show.

In addition to the vent flue, there must, for the sake of establishing healthful conditions through proper ventilation, be means provided for the ingress of fresh air. The projection room is often (we might almost say usually) located immediately under the roof of the building, and in consequence is, in summer time, very hot with "natural" heat. Add to this the heat generated by the powerful arc lamps, as well as perhaps one or two rheostats, and you have a condition which makes good ventilation absolutely imperative.

In connection with this it must also be remembered that air taken from the auditorium will not be pure air, and where the projection room is near the ceiling will be the warmest air in the theatre.

It must also be remembered that if it is taken in through the lens and observation ports a draft is created through them which blows directly upon the projectionist, a fact which has sent many men to their death through pneumonia brought on by "cooling off" in the draft before an observation port after some rapid repair work in an overheated room.

Where the theatre is provided with a ventilation system thorough ventilation for the projection room may be had by including it in the ventilation scheme. Where there is no such ventilation, then there should be inlet air ducts from the outer air, these inlet openings to reach the projection room near the floor line. The Massachusetts law is very good in this respect. It reads as follows:

Projection rooms to be provided with an inlet in each of the four sides, said inlets to be 15 inches long and 3 inches high, the lower side of the same not to be more than 2½ inches above floor level. Said inlets to be covered on the inside by a wire net of not greater than ¼-inch mesh; netting to be firmly secured to the asbestos board by means of iron strips and screws. In addition to the above there shall be an inlet, in the middle of the bottom of the projection room, if possible; otherwise in the side or rear of the projection room, not over 2½ inches from the floor. Said opening to be not less than 160 square inches area for a No. 1 projection room, 200 square inches area for a No. 2 projection room, and 280 square inches area for a No. 3 projection room; connected with the outside air through a galvanized iron pipe with a pitch from the projection room downward to the outside wall of the building. The opening to be covered with a hood, so arranged as to keep out the storm, and the entrance to the projection room to be covered with a heavy grating over ½-inch wire mesh, if in wall; and arranged with damper hinged at the bottom, and rod or chain to hold said damper in any position. Mesh and gratings to be securely fastened in place, those in the walls to be bolted on as specified for the smaller inlets.

Note—No. 1, No. 2 and No. 3 refer to the size of rooms.

PROJECTION ROOM EQUIPMENT.—Remembering that the box office receipts of a motion picture theatre to a very great extent depend upon the excellence of results upon the screen, the wise exhibitor will bend every effort toward the attainment of high class, artistic projection, and will put forth every reasonable endeavor to secure a high class, brilliant, flickerless picture, projected at proper speed. It may be put forward as a statement of incontrovertible fact that there is small probability of continuous high class screen results coming from an ill-placed, small, poorly ventilated projection room, poorly equipped with facilities and tools, and having inferior or badly worn equipment under the charge of a projectionist of mediocre ability. No one will, we think, dispute the proposition that the above combination would react seriously upon box office receipts.

We believe everyone will agree that the best results will be had from a properly located, commodious, well ventilated projection room, equipped with up-to-date projection machinery which is kept in good state of repair, and with ample tools and facilities; the whole being in charge of a thoroughly competent projectionist; the term "competency" including industry and careful attention to detail, as well as knowledge.

In this connection it is well to bear in mind the fact that **the mere possession of knowledge counts for very little if its possessor is too lazy or too shiftless to apply it in practice.**

CLOSETS.—In planning the projection room the architect should include sufficient cabinets, or closets, with substantial locks thereon, so that each individual projectionist may have a place to keep his private belongings, including tools. The projectionist should have a full equipment of tools, but it is rather discouraging to provide them and then be compelled to leave them at the mercy of anyone, from the janitor to a chance visitor, to say nothing of the other projectionist who perhaps has none of his own, and moreover may not be inclined to take the best care of those belonging to others.

There should also be drawers, or a closet in which to keep supplies, such as carbons, extra lenses, etcetera, though, of course, a shelf will do, and if the walls be built of cement it is a comparatively simple matter to provide cement shelves when the room is constructed. There should also be plenty of hooks on which to hang spare wire, etcetera. It is an exceedingly unprofitable thing to spend time hunting for a piece of wire, a tool or some needed repair part when something goes wrong.

It is of the utmost importance to orderly procedure and rapid work in a projection room that things be kept in their place, but in order to keep things in their place it is necessary to have a place to keep them in, and that is some-

thing it is up to the designer or architect to provide for when the room is built.

If no conveniences are provided the manager cannot very well blame the projectionist if things are not kept in order, but if conveniences are provided and the projectionist does not keep things in order, then he is not a fit man to have in charge of the projection room.

RUNNING WATER, TOILET.—It is highly important that there be a wash basin with running water, and a toilet either in or convenient to the projection room. Both of these are very essential, and the latter exceedingly so where there is only one projectionist. The basin is necessary because often something will go wrong with the machinery and the projectionist will get his hands covered with oil and dirt in making necessary repairs. He will also get carbon dust on his hands when trimming the lamp, and if there be no means of removing this grime, the next time he handles the film it is more than likely that considerable damage will be done to it. Moreover, he is apt to soil everything he touches. The installation of a wash basin and running water is, therefore, highly important. Toilet facilities should be required by law, since in many cases the projectionist cannot leave the projection room for hours at a stretch.

PROJECTION ROOM CHAIR.—Some theatre managements will not allow their projectionist to use a chair. This is, we are firmly convinced, not only a mistake, but a very serious one. One thing imperatively necessary to high class projection is that the projectionist remain constantly at his post beside the projector. Exhibitors constantly and rightly complain that projectionists will not remain at the observation port, where they belong, and that the projection in their theatres suffer by reason of this fact.

We believe there is several times the likelihood that a projectionist who is standing on his feet will move around the room than there is if he is seated. The man who is seated at his projector in front of the observation port is likely to stay seated unless something happens which requires that he get up. The idea that a projectionist seated beside his projector cannot do just as good work as he would if standing up is pure nonsense. When the author was a projectionist he always did his work seated beside the projector. Standing several hours on his feet in one position or place would have been to him almost an impossibility. He was entirely able, while seated at the projector, to make any necessary adjustment, and to make it just as quickly as though he were standing. If anything happened it required about 1/10th of a second for him to rise. There is neither rhyme, reason nor common sense in the refusal of a chair to the projectionist. The wise manager instead of refusing the chair would see that one was placed at each projector, and demand that the projectionist use it, on the theory that when using the chair he would "stay put" where he belongs beside the projector while the show is running.

PROJECTION ROOM REELS.—For many years the Projection Department of the Moving Picture World has recommended that theatre projection rooms be equipped with a full complement of projection room reels, and that **the reels upon which the films are received from the exchange be only used in the upper magazine of the projectors the first time the films are projected (not even then if the films be first rewound or inspected), and on the rewinder when the film is rewound for the last time before shipment to the exchange.**

Excellent reason for this recommendation is found in the utterly wretched condition of the great majority of reels used by exchanges for shipping films to theatres, and in the further fact that many exchanges have in the past purchased, and at this time (1922) still are purchasing, are too cheap, flimsy and rough to be fit for use on a projector, or for anything else, for that matter.

A literally enormous amount of damage to film is caused by crooked, rough reels, and reels having a too-small hub diameter. Such reels are an outrage upon common sense, and the fact that exchanges purchase and use them, or have purchased and used them, is by no means complimentary to the good business judgment of exchange owners and managers. An exchange may "save" ten cents by winding a new roll of film on a bent, rough, cheap reel, and may, in the process, lose many times that sum by the actual, though not always visible damage done to the film itself.

At the time of the compilation of this book two really excellent projection room reels were presented for examination and test; also at least one more was in process of making. Both those presented were of such construction that they deserve commendation, and both are therefore recommended to the favorable consideration of users of this book.

FILMFAST REEL.—The reel known under the trade name of "Filmfast Reel" is designed wholly for use in the projection room. It is a substantial, well constructed reel from every viewpoint. The patentee of the reel is Walter I. Tuttle, president of the Frank Mossberg Company, the address of which firm will be found in their advertisement elsewhere. The dimensions of the reel are 14⅜ inches outside diameter, with a barrel (hub) diameter of 4¾ inches. In and on the hub, or "barrel" is an excellent film gripping arrangement, which facilitates threading by enabling the projectionist to readily attach the end of the film to the reel with one hand.

Figure 90a.

The sides of the reel are of heavy sheet steel, of a quality selected entirely with reference to the duty it has to perform. The sides are heavily embossed, which together with the heavy weight metal will prevent kinking, bending or warping even under pretty rough usage. The hub construction is very substantial. It has a central half-inch-diameter stud, drilled and reamed to fit accurately on the take-up spindle. This stud is a driving fit into a heavy washer at each end, which prevents the key ways from spreading. The two washers are joined to each other through the side plates by means of three studs which are riveted into the washers.

The barrel (hub) is attached to each of the reel sides by means of twelve metal ears, which same are clinched down tight. On the outer surface of the barrel (hub), and concentric with it, is a heavy spring attached to its middle portion. To either end of this spring is attached triggers, which same extend within the barrel and form a gripping arrangement for the finger, as is shown in Fig. 90a. The projectionist pulls on the trigger raising the end of the spring, and with the thumb of the same hand slips the film end under the spring. It is all done with one motion and with one hand, and is a positive gripping of the film end.

The "Filmfast" reel will be shipped you packed in individual corrugated paper cartons, which insures their receipt in good condition. We recommend the reel to your favorable consideration.

SIMPLEX AUTOMATIC SIGNAL REEL.—The Precision Machine Company, Inc., manufacturers of the Simplex projector, is marketing a projection room reel under the above name. This reel appeals to us as a very practical, high grade proposition for projection room use.

Figure 90b.
Filmfast reel with sides removed showing hub construction.

In the first place, as will be seen in Fig. 90c, the sides are of steel wire, about 5/64th of an inch in diameter. The loops are connected to the hub, which is five inches in diameter, in the way shown in Fig. 90c and Fig. 90d, in viewing which you will understand that the outer shell of the hub (F in Fig. 90e), has been removed in order to show the method of connecting the loops to the hub studs, the center hub itself and the automatic signal device.

The construction as a whole embodies the following substantial points of advantage:

(A) The reel is substantial and rigid.

(B) It is difficult to bend, and the bending of the reel at one point does not affect other portions of the reel; also the zone which is bent may be straightened and the reel again be made perfect, something which, so far as we know, cannot be done with any sheet metal side reel.

(C) The form of construction and the form of material used effectually prevents the cutting or scratching of film, or the cutting or scratching of the projectionists' hands, both of which are very common with the cheap sheet metal side reels now in general use.

(D) The open construction of the reel is such that, while it affords ample protection to the film, it makes the reel very accessible for threading, etc.

(E) The hub of the reel is the best we have yet seen, in

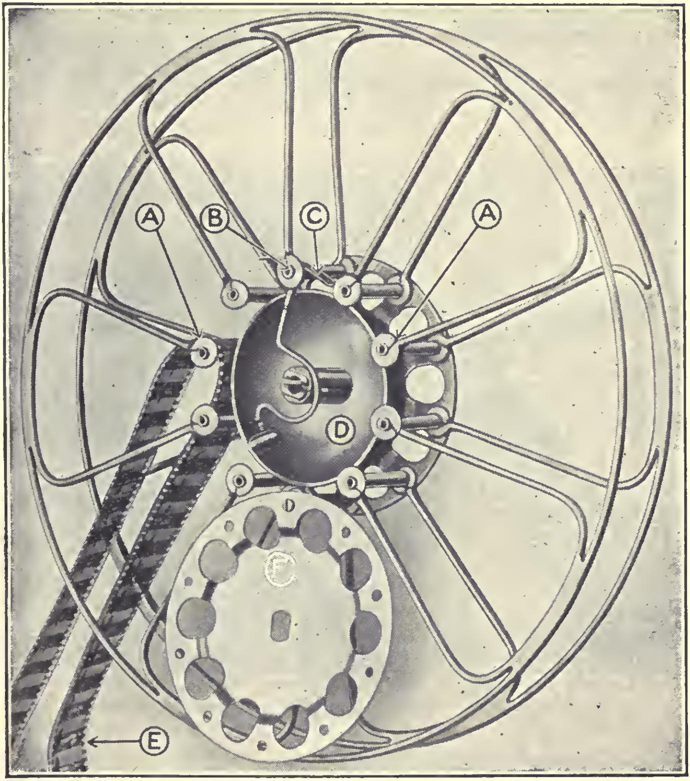


Figure 90c.

that it consists of a solid cylinder of steel, through which a hole is drilled to receive the spindle of the take-up or rewinder. In either end of this steel hub a slot is cut clear across the hub, thus forming a double-sided key way. This renders it exceedingly improbable, if not impossible that the key way will ever wear out, and that is one of the weak points in all old style reels; in fact it might be truthfully said that the weakest point of the many weak points in old style reels was the key way.

(F) In its center, within the hub, the reel contains an automatic dissolving signal, as will be explained further along.

IN THREADING the reel the projectionist passes the end of the film under either one of studs A A, Fig. 90c, **both of which are bright nickeled,** being certain the end of the film is underneath, as per Fig. 90c.

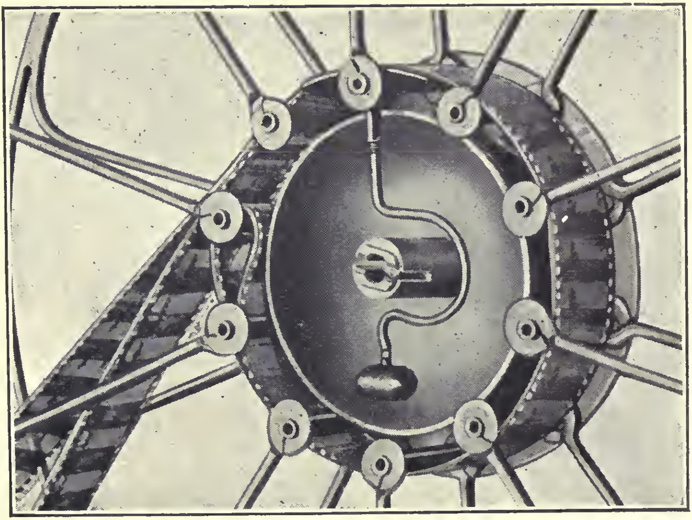


Figure 90d.

IMPORTANT.—The time you will have for making the dissolve after the signal is given, depends, within reasonable limits, upon the length of the end of the film pulled under stud A. The longer this end the more time there will be after the signal sounds before the screen goes white.

When you have end E as long as you wish, you must give the reel at least one full turn in the direction it normally runs, which not only locks the film by friction upon itself but does another important thing, viz.: Mounted on stud B is pivoted arm C, to which the gong hammer is attached, as shown. When the reel is given a turn or more to lock the film to the hub by friction, it pulls arm C into position which holds the gong hammer in the position shown in Fig. 90d. The action is as follows: Mounted within the shell of the hub is a 4-inch diameter gong, marked D in Fig. 90c. So long as arc C is held in position, as per Fig. 90d, by the film, the hammer cannot strike the gong, but when the last layer of film unwinds in process of projection, arm C is released and thereafter at every revolution of the reel (and the reel is then revolving rapidly) the hammer will strike the gong, which is the signal for immediate change-over—in other words a signal to immediately dissolve and change to the other projector.

We can recommend the Simplex Automatic Signal Reel to the favorable consideration of our readers.

PROJECTION ROOM SUPPLIES.—It is impossible to imagine a more foolish and utterly mistaken policy on the part of a theatre management than niggardliness in the matter of projection room supplies. The suspicion held by some theatre managers that if they do not constantly "sit on the lid" in the matter of projection room supplies waste will occur, is as foolish as it is unworthy.

The projectionist who cannot be trusted to be careful and economical with supplies is not a fit man to be in the projection room at all.

Many theatre managers, however, have a mistaken idea of what constitutes economy in supplies.

The competent projectionist does not wait until a part breaks down entirely, thus perhaps stopping the show until repairs are made, nor does he wait until a part is so badly worn that the screen result is made to suffer. He renews parts before a break comes or before there is damage to the screen result.

From any and every viewpoint it is false economy to attempt to get the last possible bit of wear out of projection room equipment. Take, for example, asbestos wire lamp leads. Entirely too many projectionists use their lamp leads, particularly that portion inside the lamp house, altogether too long. Inside the lamp house the wires are subjected to increasing heat from the arc as they approach nearer to it, and as the temperature of metal rises its resistance also rises. Copper oxidizes under the action of heat, and where a wire which is working close to capacity electrically is subjected to the action of heat from an outside source, the effect is to raise the resistance of the wire, thus lowering its carrying capacity and setting up still more heat and rapid oxidization and deterioration. In a very short time the strands of the asbestos wire inside the lamp house turn brown, then dark brown.

If you strip back the insulation you will probably find the wire to be discolored for a considerable distance. Under this condition its resistance is very high, and since resistance means loss which is registered on the meter, the wire is consuming within itself, by reason of its high resistance, wattage which in a few hours' time will more than equal the cost of the wire, modified, of course, by the fact that if current is taken through an adjustable rheostat there may be no actual loss, as that much less resistance will be required in the rheostat. But the condition is a bad one nevertheless.

Yet it is a fact that many theatre managers, lacking knowledge of such matters themselves, and unwilling to trust the knowledge of their projectionist, protest against the cutting off of burned wire, and demand that it be used longer. They are "saving" a few cents in wiring deplacement at the expense of a great many cents in electrical energy.

There is always a tendency to use the intermittent sprocket of the projection machine too long, with consequent damage to the film and to the screen result, and anything which damages the screen result is expensive, because the public patronizes a theatre in proportion to the pleasure it gets out of what it sees on the screen.

I mention these two examples merely as being typical, and place them in evidence as showing that it does not pay to be too economical in the matter of projection room supplies; also as proof that lack of knowledge often causes a theatre manager to practice that which is in fact false economy; in other words to practice economy which is as a matter of fact not economy at all, but exactly the opposite.

It is the part of wisdom for the theatre manager to employ only projectionists in whose ability he has at least a reasonable amount of confidence, and having done so to allow them a reasonably free hand in the matter of projection room supplies.

As a matter of business the theatre manager may very well require his projectionist to keep a record of (a) all supplies purchased, (b) make weekly report of repairs and replacement, and (c) that all old machinery parts replaced be delivered to the manager's office.

PROOF.—In proof that it does not pay to be too economical in supplies, let us cite the following: We believe almost any projectionist will agree to keep both projectors in first class condition for a year for the sum of $150, this not to include ordinary deterioration of the machine as a whole, but merely a sufficient replacement of worn parts to keep the projectors in first class repair. $150 a year amounts to $41^{1}/_{10}$ cents a day. A theatre of 700 seating capacity giving four shows a day has 2,800 seats to sell, or 2,800 admissions to dispose of each day. Supposing the admission price to be 15c., it would only require the price of less than three seats to keep the projection machines in absolutely first class mechanical condition, and

Is there a theatre manager on earth who does not realize and know that projectors in first class mechanical condition will produce a sufficiently better screen result than projectors in poor mechanical condition, to increase seat sales by an average of three a day out of 2,800?

NEW PROJECTORS VERSUS OLD.—The foregoing argument applies equally well to the projector as a whole. Let us assume John Jones to own a theatre having 700 seats, giving four shows a day. He therefore has 2,800 admissions for sale each day. Let us assume his admission price to be 20 cents. John Jones has two old type projectors which should have been thrown into the scrap heap long ago. He says he cannot afford to replace them with new projectors. Let us examine into the matter.

Two new projectors of late type would cost him let us say $1,200 for the sake of easy figuring. Let us further assume that the new projectors will last three years, at the end of which time they will be utterly useless. In other words, that John Jones, after using the new projectors three years, is going to throw them into the scrap heap as having no value at all. Let us also allow 8 per cent. interest on the investment. This means that John Jones is going to invest $1,200 in projectors, which at the end of three years will be entirely worn out. He will also lose the interest on that sum for three years, which at 8 per cent. amounts to $288. John Jones therefore stands to "lose" $1,488 in three years if he buys two new projectors. This means that in

1,095 days 148,800 cents will have been "used up." This is an average of about 135 cents a day, or the value of less than seven admissions at 20 cents each.

Does that exhibitor live who honestly believes that two new projectors will not produce a sufficiently better screen result than his worn and more or less out-of-date projectors to increase the patronage of the theatre which has 2,800 seats (or even a much less number) to sell every day by decidedly more than six additonal admissions?

We thus see that, as a plain matter of common sense, John Jones CAN afford to put in new projectors; also that he is actually losing money every day he delays doing it.

The projection room should have an ample supply of carbons and all those various repair parts and other things necessary to the keeping of the equipment in first class condition. It is impossible to enumerate the various things, because they will, in the very nature of things, vary considerably in different projection rooms.

The things we seek to do in the matter of projection room supplies is not so much to supply a list, which may or may not fit the individual requirement, but to impress upon the mind of the theatre management the fact that "scrimping" in projection room supplies is, in the long run, not true economy, and may actually be a great source of waste.

AN EXCELLENT FILM CABINET.—The American Film-Safe Corporation, Baltimore, Md., is putting out a film storage cabinet which we regard as being pretty nearly ideal. In fact we very much doubt if the general design of this particular piece of projection room equipment will ever be very much improved upon, though that prophecy does not extend to structural details. The cabinet seems to combine about every desirable feature, in that it is fireproof as a whole and as applies to individual reel containers, is handsome in appearance, rigid in construction, very elastic as to capacity.

In Fig. 90A we have a view of the cabinet, which is named the Safe-T-First Film Cabinet, with the notation that in its final design each section holds five (5) reels, whereas the one shown accommodates three reels to the section. As it now is the 5-reel section is the minimum. The 3-reel section is no longer made.

The cabinet is of all steel, insulated construction. In appearance it exactly resembles the rather handsome cabinet document files seen in many offices. Each handle is attached to and operates the door of a single reel compartment, which same is fire insulated from every other single reel compartment. Each of these single reel compartments is, or may be, connected either with the open air or with the projection room vent flue, through the cabinet vent pipe. In other words, the vent pipe top, or cone, seen at the top of the cabinet in Fig. 90e, connects directly with every one of the single reel compartments of the cabinet, hence should a reel in any one of the compartments catch fire, it would, due to the very limited air supply, burn very slowly, all the smoke being conveyed directly away and out of doors. This feature alone we regard as of distinct value.

Figure 90e.

In Fig. 90f we see one of the sections being lifted away. Remembering that the Safe-T-First cabinet sections may not be had in less than 5-reel capacity, it is seen that any desired capacity may be had in a single cabinet by piling as many sections as desired, one upon another; each compartment connecting with the vent flues of the other sections, as shown in Fig. 90f the flues of the upper section being capped by the cone shown in Fig. 90e.

INDIVIDUAL LOCKS.—Each individual reel compartment may be provided with a lock, if so ordered; also each compartment is self closing. By opening the compartment the reel is automatically moved to the position shown in Fig. 90e.

You cannot leave a compartment open, unless you deliberately block it open, because it closes automatically by its own weight.

This cabinet has the hearty indorsement of the author of this book and of the Projection Department of the Moving Picture World. They are well worth their price.

THE REWINDER.—The rewinder may be located either in the projection room or in a room immediately adjoining. It will pay the projectionist to give a little thought to the arrangement of his rewinding table. In the first place **it is of huge importance that the two elements of the rewinder be in perfect line with each other, since otherwise the edge of the film will rub on the edge of the reels during the whole process of rewinding, with resultant weakening of the film track, especially if the sides of the reel be bent or crooked.**

Figure 90f

We cannot emphasize too strongly the importance of carefully lining the two elements of the rewinder. Damage aggregating thousands of dollars a day is done to film by rewinders because of the two elements being out of line with each other.

The two elements of the rewinder should be placed a convenient distance apart, carefully lined with each other and fixed firmly and permanently in position so that they cannot possibly get out of line. Between the two elements of the rewinder a hole about 3 inches wide by 4 inches long should be cut in the rewinder table. This hole should be covered with a piece of thick glass, the top of which should be thoroughly ground by rubbing it with fine sandpaper, or with fine sand under a piece of flat stone or iron. Under this glass install a small incandescent globe, and just back of it cut a hole in the table to receive the cement bottle. You thus have everything convenient for making splices.

The rewinder should in all cases be motor driven and

The speed should be geared down by means of suitable pulley wheels or gears until at least 8 minutes is consumed in rewinding 1,000 feet of film.

Rewinding film at high speed is bad practice. If the rewinding be done at the rate of 8 minutes to the thousand feet (10 is better) the film will be rewound in ample time to make room for the next reel, in theatres where sane projection methods are practiced, and there will be no necessity to watch the process of rewinding, unless there are repairs to make. There should be an arrangement which will automatically stop the rewinder motor when the process of rewinding is finished. This may be done in any one of a dozen ways, all of which have from time to time been described in the projection department of the Moving Picture World. Where the motor rewind is used a brake should be provided for the reel from which the film is being rewound, and there should be just sufficient tension to cause the film to be rewound snugly.

Pulling down of film (holding one reel stationery and revolving the other to tighten the film roll thereon) is productive of enormous damage to film in the form of scratches made as the layers of the film roll slip on each other. These scratches later fill up with dirt and form the rain marks with which we are all so familiar. If rewinding be done by motor, and be done slowly, with plenty of tension on the reel from which the film is being rewound, there will be no necessity for "pulling down," and thus much damage to film will be avoided.

Another argument in favor of the slow motor rewind is that where rewinding must be done by the projectionist, if the speed of rewinding be slow and the rewind be motor driven, there is no necessity for the projectionist watching the process. He is therefore free to attend to his other duties, and if the rewinder be so arranged that the motor will automatically stop when the process of rewinding is finished, the only attention the projectionist need give the process of rewinding is to take off the rewound reel, put it in the storage case, put on the reel to be rewound and start the rewinder going. This, of course, being true only when there are no repairs to be made.

For the purpose of making repairs it is, perhaps, best to install a separate hand rewinder. In this connection, we would recommend the installation as a part of the projection room equipment of the film splicer made by the General Machine Company, 363 East 155th Street, New York City. We have had this little device very thoroughly tested. It is low in cost and operates perfectly. See Page 277.

AMMETER AND VOLT METER.—In the judgment of the author it is an exceedingly good investment to provide the projection room with an ammeter and volt meter, particularly the former, and to locate them in such position that they will be constantly in view of the projectionist when he is in working position at the projector. The ammeter should be connected to the projection circuits in such way that it may be used to indicate the amperage of either arc.

There is a certain point at which the projection arc will produce maximum illumination with a minimum of current consumed. Just a slight movement of the carbons away from this position will raise the current consumption anywhere from 5 to 20 per cent., without in the slightest degree increasing the screen brilliancy—in fact it is likely to decrease it. With an ammeter placed directly in view of the projectionist he is able to, and if he is a careful man will, maintain his arc at the point of maximum brilliancy with a minimum current consumption. We are firmly convinced that in the average theatre a projection room ammeter, **if properly located,** will pay for itself in a very short time. A very good ammeter and volt meter may be had from the United Theatre Equipment Corporation, 45 West 45th Street, New York City. The method of connecting an ammeter and volt meter is shown in Fig. 91.

ANCHORING THE PROJECTOR.—With modern late type projectors anchoring is not of such prime importance, since the weight of the machine itself is sufficient to hold it steady, and pedestal projectors are designed to be bolted to the floor. Anchor bolts may be set in a cement floor by drilling holes about 3 inches deep in the cement, setting the bolt head down in the hole, and pouring the hole full of melted solder. With the lighter machines, however, many of which are still in use, the anchoring of the machine to the floor is important, since the slightest vibration or movement of the projector will produce unpleasant results upon the screen. The old style tables may be anchored down by the use of screw eyes set in the floor, wires attached to the machine table and to the screw eyes through a "turn buckle" such as may be had from any hardware store. We do not believe a detailed description is necessary, because the importance of anchoring a light machine is self-evident, and certainly any man fit to be a projectionist would have sufficient ingenuity to find a method of securing the desired result.

TOOLS.—The projectionist should be in possession of a kit of tools enabling him not only to do any work incident

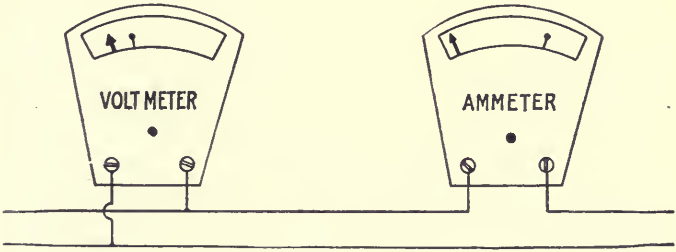


Figure 91.

to projection, but small repair jobs as well. Such a kit will cost quite a bit of money, but it is a good investment. The manager is likely to have a great deal more respect for the projectionist who owns a good kit of tools than for one who owns a ten cent screw-driver and a pair of pliers.

In the third edition of the handbook we gave a list of tools, to which we see no reason for either adding or subtracting, except to remark that the management should provide a small hand bellows, particularly if a motor generator set to be used. This tool should be a part of the projection room equipment. It is used for the purpose of blowing out dust and dirt from around the armature and pole pieces from the motor generators. The following is the list of tools:

One pair "button" pliers 8 or 10 inch; one pair 8 or 10 inch lineman's side cutting pliers (we leave the matter of size open, as some prefer one and some the other); one pair 8 or 10 inch gas pliers: one large and one medium screw-driver; one screw-driver with good length of carefully tempered blade for small machine screws, to be heavily magnetized so as to hold small screws; one pair of pliers for notching film, see page 288, one small riveting hammer; one carpenter's claw hammer; one small cold chisel; one medium-sized punch; one very small punch for star and cam pins; one small pair tinner's snips; pair blunt-nose film shears (such as clerks use); one small gasoline torch for soldering wire joints; one hack-saw. With this kit you will be able to do almost any ordinary job, but you will have use for them all. In addition to the above the house manager should furnish one 8 and one 10 inch flat file, one ⅝ round file, one 8 inch "rat tail" file, a small bench vise with anvil and some soldering flux and solder wire, and a film splicer.

Of course many projectionists will wish to add to this kit, but what we have named will serve very well, taken in conjunction with the files and other things furnished by the management.

SMALL, PRACTICAL BLOW TORCH.—Realizing that in order that wire joints be properly made, and that wires be properly soldered to terminal lugs at switches, fuse block terminals, etc., it is essential that the projectionist have a blow torch; also realizing that the average projectionist will not go to the expense of purchasing a large blow torch, and that if he did it would be an unwieldy thing in the tool kit, we have for several years tried to find a small torch, which while a substantial and a practical tool, was one which would not go "blooy" in a few weeks or months. It was a hard thing to find, but we have at last succeeded.

Messrs. Baum and Bender, Newark and Jersey City, New Jersey, make such a tool. Price, post paid, $1. Weight 5 ounces. Size 5 inches long by about 1 inch in diameter: Material solid brass throughout, except for a wick and small rubber tube about a foot long. Flame: very hot and about ¼ inch in diameter by 2 to 2½ inches long. Fuel: wood or denatured alcohol. Cost of operation, almost nothing.

OPERATION.—Unscrew lower end cap and fill with alcohol. Replace lower cap and remove upper end cap. Blow through hose and adjust blow-hole to proper height as per instructions accompanying torch. That is all there is to it. The torch is NOT good for any but very small jobs, and for wire joints. It should, except for renewal of the rubber hose (cost about 10 cents), and the wick (probably 5 cents) perhaps once a year, last for years, provided you don't allow it to get smashed. We recommend it to you for the purposes named.

TOOLS IN ORDER.—It is of the utmost importance that the projectionist's tools, be they many or few, be kept in order, neatly arranged on the wall, the screw-drivers and pliers within handy reach. One of the most reprehensible habits possible is that of dropping tools when one has finished using them and letting them lie until needed again.

It would be hard to estimate how many thousands of times moving picture theatre audiences have sat in the dark, waiting patiently while a projectionist searched for the pliers, screw-driver, or other tool needed to make a repair, which he had thrown down wherever he happened to use it last. Often I have gone into projection rooms and found the tools lying on the floor in a jumbled pile underneath the projector. This kind of thing is not only exceedingly unworkmanlike, but also is decidedly sloppy. The man who does things that way is unlikely to make any large success, either of projecting or anything else.

My advice to the projectionist is have a good kit of tools and keep them neatly arranged and in perfect order.

My advice to the manager is to discharge the projectionist who is satisfied to own only a pair of pliers and a screw-driver, or who, having other tools, does not keep them in order. If he is unworkmanlike in so important an item, it is likely he will be unworkmanlike in other things which will reflect directly on the screen in the shape of faulty projection.

ANNOUNCEMENT SLIDES.—It is frequently necessary to make announcements to the audience. There are a great many different ways in which very good appearing slides can be quickly prepared. There are inks on the market, in several colors, with which one may write, using an ordinary pen, on clean, plain glass, just the same as he could write on paper. There are also a number of slide coatings for sale on which writing may be done with a pointed instrument. These slide coatings are particularly to be desired for any slide which must be made on the spur of the moment, by reason of the fact that a number of them can be gotten ready and laid up on a shelf in a pile, where they will keep indefinitely. If anything happens and you wish to say something to the audience, the projectionist can write on these slides with anything having a sharp point. For instance, suppose something occurs that will cause a delay of two minutes. Within five seconds the projectionist can write on one of these slides "Unavoidable Delay of Two Minutes," stick it in the stereopticon and project it to the screen. The audience will then be satisfied to wait for that length of time. I only suggest this as one possible way in which slides of this kind may be utilized. They should be kept in the projection room ready for instant use. Please understand in this I am not referring to program slides which the manager himself will wish to prepare, but merely these designed to be used for emergencies. See Page 811.

WIRING THE PROJECTION ROOM.—The wiring of the projection room is a matter which should be carefully planned before the construction of the room is begun, especially if the walls in which the conduit is imbedded are to be of concrete or brick.

The projection room service wires must, of course, be large enough to carry the entire load of the projection room without overload, and with only about 2 per cent. voltage drop. By this we mean that if there are, for instance, two projection lamps, a dissolving stereopticon, a spot light and four incandescent lamps; the projection room feed wires must be large enough to carry the combined amperage of all these lamps when they are all burning; though they need only operate at 2 per cent. voltage drop at the normal load used. It is quite true they are not likely to ever be all in use at one time, but this doesn't alter the fact that the correct procedure is to make the wires large enough to supply them all without overload.

The necessary amperage capacity of the projection room feed wires is computed as follows: First estimate the combined amperage. Suppose there are two projectors and you propose using 60 amperes at the arc of each through resistance. This would call for $60 + 60 = 120$ amperes at the two projector arcs. The dissolving stereopticon will, if one be used, probably require a total of 30 amperes for the two lamps, and if there be a spot light 25 amperes will probably serve for it. We will assume the incandescents to require five amperes. We thus have $120 + 30 + 25 + 5 = 180$ amperes. Turning to table 1, Page 70, we find that if the service circuit be 2-wire it will be necessary to install No. 000 wires to carry that amount of current without overload, modified by the fact that length of circuit forms an element which must be reckoned with. See "Figured Voltage Drop," Page 74.

If the feeders are 3-wire, then, since when the lamps are all in use one-half would burn in series with the other half; providing the balance be perfect (see 3-wire system, Page 85), the amperage requirement would thus be cut in half and No. 2 wires would serve, again provided length of circuit be not too great.

If the projection room service circuit be 3-wire, but it be required that the projection arcs be connected across the two outside wires on 220 volts, then it would be necessary that the two outside wires have the same capacity as though it were a 220 volt 2-wire system.

However, regardless of what the condition may be, the projectionist should figure the voltage drop as per the formulas laid down on Page 74, since voltage drop due to too high resistance of the projection room service wires will be registered on the meter, and must be paid for just the same as though the current were consumed at the arcs, modified when current is taken through adjustable resistance. In that case the excess resistance in the wires may be compensated for by using less resistance in the rheostat, but the condition, nevertheless, is a bad one.

If all the lamps be operated from motor geenrator set, rotary converter or motor arc rectifier, or through a low voltage transformer (economizer, compensarc, inductor, etc.) then the projection room service wires need only be large enough to supply the primary capacity of these devices, always assuming the aforesaid motor generators, rectifiers or transformers are to be supplied by the projection room service circuit. If they be located in the basement or elsewhere and the projection room be supplied by wires from them, then, of course, since these wires will carry the secondary current, their size must be figured on that basis.

In Fig. 92 the general layout of a projection room switchboard is shown. There should be a main switch (A) supplied with link fuses (B-B-B). This switch and the fuses carry the entire projection room load. The incandescent circuits should be taken through a separate circuit controlled by a separate knife-switch as per C. Cut out blocks D-E-F (there may be as many as are required), carry fuses for the various circuits and, if desired, switches also. In Fig. 92 we will assume circuits 1 and 2 supply the projector arcs, circuits 3 and 4 the dissolving stereo circuit and circuit 5 the spotlight. This layout is only designed to be suggestive. It shows how a very acceptable projection room

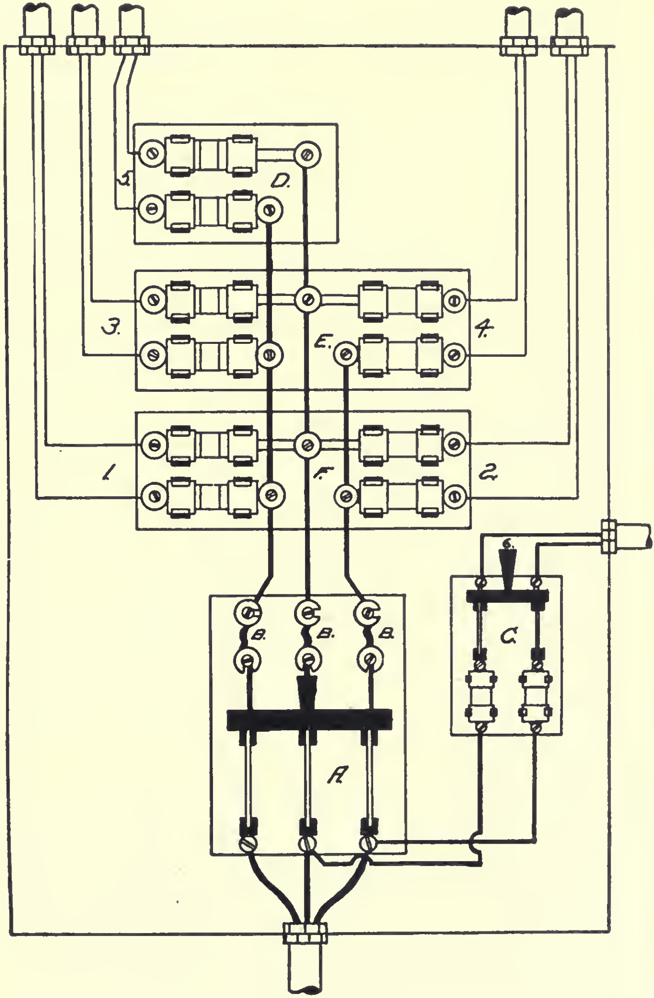


Figure 92.

switchboard may be built up from switches and fuses mounted on a suitable insulating base. The board shown in Fig. 92 is built of ⅜ inch asbestos mill board and is enclosed in a metal cabinet similar to the one shown in Fig. 17, Page 104, only larger. This type projection room switchboard may easily be constructed by using slate-base knife-switches equipped with fuses, if it is so desired; and it is quite practical to use link fuses instead of cartridge fuses. In fact in some cities this is required by law for projection circuits.

BALANCING THE LOAD.—Where a 3-wire service circuit supplies the projection room, and it is permitted that connection be made to the neutral, the power company should in all cases be consulted as to how they would prefer to have the projection arcs connected. It is, of course, impossible to balance the projection room load on a 3-wire system, because ordinarily only one projection arc will be burning at a time. This, however, does not apply to the dissolver, the arcs of which should always be connected to opposite sides of the system, since when the dissolver is used its load will be perfectly balanced between the two sides. If both dissolver lamps were connected on one side, when the dissolver is in use, it would have an unbalancing effect of whatever the capacity of the two dissolver lamps may be. Ordinarily it would be undesirable to connect both projection lamps to one side, particularly if you are using high amperage, because when the arc of the idle projector is struck to heat the carbons before it is time for a change over, for a short time the entire load of both projectors would be on one side of the system, which would mean an unbalancing effect of anywhere from 60 to 200 amperes (or in some cases even more) which would be sufficient to be objectionable even on a system, supplied by large generators.

As a rule power companies will always want projection lamps connected on opposite sides, but as we said in the beginning it is good practice to consult them in a matter of this kind. In the foregoing we are assuming the arc lamps to be taking current directly from the mains through resistance.

CONNECTING MOTOR GENERATORS, ECONOMIZERS, ETCETERA.—Where current is taken through a motor generator set, and the supply lines are 3-wire, we would recommend the purchase of apparatus having a motor of the voltage of the two outside wires. This not only avoids any unbalancing effect, but has the additional advantage that high voltage motors work more efficiently than the low voltage machines.

Where current is taken through a mercury-arc rectifier, and the projection room is supplied by a 3-wire system, we would recommend that the rectifier be connected across the two outside wires, which may be done merely by making the proper internal connections in the rectifier itself. See Page 522.

Where projection current is taken through low voltage transformers (economizers, inductors, compensarc, etc.) and the projection room feeders are 3-wire, it is better to purchase an economizer to operate on a voltage of the two outside wires. Such an economizer is just as efficient as the one of lower voltage, and the unbalancing effect is thus avoided.

The location of the projection room switchboard cabinet will necessarily be determined by local conditions, but it should be remembered that inconveniently located apparatus invariably tends to decrease efficiency of operation.

There is nothing to be gained by making things inconvenient for the projectionist. On the other hand there is much to be lost by so doing.

PROJECTION ROOM FUSES.—We would suggest that the projection room service fuses be placed as shown in Fig. 92, rather than on the other side of the main switch. Inasmuch as the projection room feeder circuit, including the main switch, is protected by fuses in the main house switchboard or elsewhere, there is no necessity for protecting the main projection room switch further; and it is more convenient to install fuses at B if the fuse block be "dead" than if it be alive, as it would be if the fuses were on the other side of the switch.

HIGH VOLTAGE THROUGH RESISTANCE.—Some power companies will not permit the neutral wire of the 3-wire system being run to the projection room. This compels the use of 220 volts, which, if rheostats be used, is very wasteful indeed. The reason for the refusal to allow the neutral to be run to the projection room is the heavy unbalancing effect of the projection arcs, as already explained. It is quite possible that this unbalancing effect may be very serious, from the power company's viewpoint, especially in a small city where there are a number of moving picture theatres and the power company's generators likely to be pretty heavily loaded. Suppose, for instance, a 3-wire street main supplies five moving picture theatres, each of which have two projectors, all connected to the same "side" of the system. It might very easily happen that the projectionists of all five theatres would chance to be changing from one machine to the other at the same time, and that all struck the arcs of their idle projector at approximately the same time. This would mean, assuming they were pulling 60 amperes at each arc, a total unbalancing effect of 600 amperes, since while the arcs of both projectors were burning each theatre would be using 120

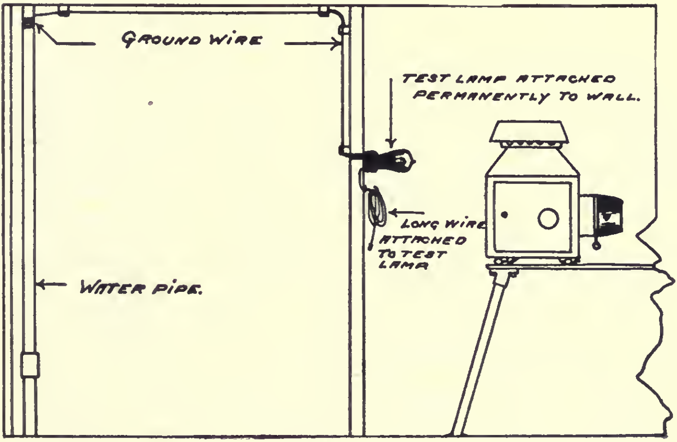


Figure 93.

amperes at its projection arcs. This would probably have the effect of very greatly overloading the generator attached to that side of that particular street main, at least temporarily. Even if these five theatres each had their two projection arcs on opposite sides, when only one arc was burning in all of them it would mean an unbalancing effect effect of $60 \times 5 = 300$ amperes, so that you see the light company is, from their viewpoint, perfectly justified in demanding that only the outside wires of their 3-wire system be used.

This does not, however, hold good if current be taken through rheostats.

In that event the compelling of theatres to connect to the two outside wires would simply mean that instead of overloading one generator by a given amount, both generators attached to the system would be overloaded that amount. Instead of one generator pulling an unbalanced load of 600 amperes, as before set forth, if connected to the two outside wires each generator would have to pull a load equal to 600 amperes at 110 volts when all arcs are burning, therefore the only result would be a big additonial (double) load on the power plant, and an entirely useless waste of electrical energy.

The reason for this is that when taking current through rheostats 600 amperes at 110 volts equals 66,000 watts, but 600 amperes at 220 volts equals 132,000 watts, the extra energy being consumed in the resistance itself.

While the light company has the undoubted right to demand that the projection lamps be connected to opposite sides of a 3-wire system when current is taken through economizers, it has no right to demand that the projection lamps be connected to the outside wires of a 3-wire system if current is taken through rheostats, since it gains absolutely nothing by that sort of procedure except the sale of double the amount of electrical energy.

Where projection current is taken from a 3-wire system through either a motor generator rotary converter, mercury arc rectifier or economizer, the power company is entirely within its rights in demanding that the theatre use the two outside wires only for projection current.

PROJECTION ROOM INCANDESCENTS.—The projection room lighting presents a very distinct optical problem, though that fact seems to be seldom realized by either the projectionist or the theatre management, and apparently is seldom realized or recognized by the architect. It is an optical impossibility to have a clear sharp view of a screen located perhaps 100 or more feet away when looking out of a well lighted room through a comparatively small opening in its wall. This is true under any circumstance, but is especially true if the walls surrounding the opening (observation port) be light in color, and since it is impossible that the projectionist judge of the fineness of focus unless he has a clear sharp view of the screen, it follows that sharpness of focus or definition will inevitably suffer if the observation port be small, and the projection room unintelligently lighted.

After visiting hundreds upon hundreds of theatres in all parts of the country the writer has never yet seen but one in which a really good view of the screen was had from a well lighted projection room. This single exception is described on Page 311, but since much time will be required to educate theatre managements and public officials to the large projection room observation port, we must in the interim deal with conditions as they are. The average projection room has a relatively small observation port, and some of them have a very small one. It is difficult to get a sharp view of the screen through such a port under any condition, and it may be stated as a matter of fact that unless projection rooms having these ports are kept dark the screen result will inevitably suffer.

In such rooms we would recommend that where the ceiling is high—say not less than 10 feet—a row of lights, say four in number, be placed at the ceiling, and as close as possible to the front wall, and then that a board or shelf be run along the entire length of the front wall extending out just far enough to prevent the light from these lamps striking the rear wall within 6 feet of the floor, the space above the shelf to be painted white.

This suggestion if properly carried out will set up as good an optical condition as could be expected, but it will not work if the ceiling is low, because in that event the light would shine directly into the projectionist's eyes.

With a low ceiling the lights may be placed at will, and switches provided so that the projectionist may turn the lights out when projecting.

Another excellent plan for projection room illumination is that used by the Cinematograph Theatres, Ltd., England. It consists of inverted bowl indirect lighting fixtures in which two distinct circuits are installed, one carrying sufficient lamps to illuminate the room very dimly, just enough to enable the projectionist to find his way about, the other circuit serving to give brilliant illumination. It is forbidden that the "bright" circuit be used except in emergency.

We would suggest that unless some such plan be adopted the management of theatres absolutely forbid the burning of any incandescents in the projection room when the picture is running, except in case of emergency or while threading the idle machine. The management has a perfect right to make this rule, because upon its observance depends, to a considerable extent, the continuous excellence of screen results.

GROUND WIRE.—It is highly desirable that a permanent, known ground be established in the projection room, and this may be best done by attaching a No. 22 or larger copper wire to a water pipe, or else soldering the end of such a wire to a copper plate not less than one foot square, and burying the plate, imbedded in powdered coke, in the ground deep enough to secure a permanent contact with moist earth. If the wire is attached to a water pipe the pipe should be scraped with a file until it is bright, the wire thoroughly cleaned and wrapped around the pipe tightly several times. It will not be practical to solder anything to a water pipe if the pipe contains cold water. Another and even better plan is to file the pipe clean and then make a band, either of brass or copper, and clamp the same to the pipe by means of small stove bolts, first having soldered the end of the ground wire to the band. Having attached the ground wire, either to the water pipe or to the buried copper plate, it should be carried to a convenient point in the projection room, and the end of it attached to one binding post of an ordinary incandescent lamp socket, as shown in Fig. 93. We then attach another copper wire to the other binding post of the lamp socket, this latter wire being long enough to reach any part of the apparatus it may be desired to test. A good place for the lamp socket is in the ceiling immediately above the projectors, unless the ceiling be too high, in which case it may be attached to the front wall between the two projectors. Having established an ordinary incandescent lamp in the socket, testing for grounds becomes a very simple matter indeed, since we have only to touch the thing it is desired to test with the raw end of the test wire (see "Testing for Grounds," Page 356.)

We are indebted to John Auerbach, New York City, for a most excellent testing installation by means of which it is only necessary to close a switch in order to test for grounds in either carbon arm, or to test the fuses even though they be located at a distant point as, for instance, in the basement.

The following is the key to the diagram shown in Fig. 93:

(A) Incandescent lamp.
(B) Incandescent lamp.
(C) Single Pole Snap Switch.
(D) Single Pole Snap Switch.
(E) Single Pole Snap Switch.
(F) Single Pole Snap Switch.

(G) Wire leading to binding post of positive carbon arm.
(H) Wire leading to binding post of negative carbon arm.
(I) Edison 3-wire system.
(J) Incandescent cutout in projection room.
(K) Projection circuit cutout in projection room.
(L) Positive fuse of projection circuit.
(M) Negative fuse of projection circuit.

That part of the diagram drawn in heavy lines indicates wiring to test for grounds in either carbon arm. That part drawn in light lines indicates the wiring to test fuses in main service fuses. The device therefore may be wired

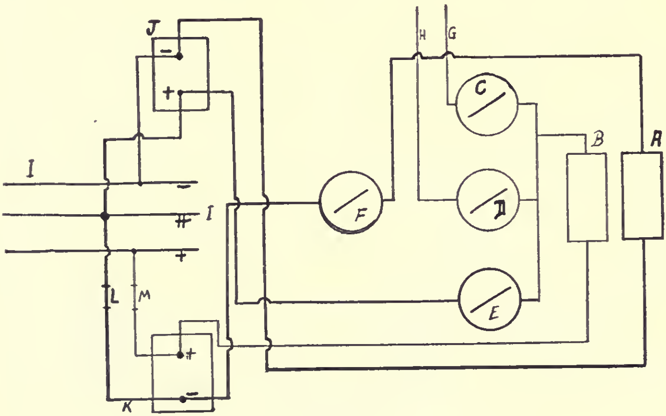


Figure 94.

for either or both of these purposes. When the tester is not in use all switches should be open.

(A) **To test for ground in positive carbon arm** close switch C. If lamp lights, a ground is indicated in that arm. If lamp does not light there is no ground.

(B) **To test for ground in negative carbon arm** close switch D. If lamp lights, a ground is indicated in negative carbon arm; otherwise not.

(C) **To test positive projection room service fuse** close switch E. If lamp lights fuse is O. K.; otherwise it is not.

(D) **To test negative projection room service fuse** close switch F. If lamp lights fuse is O. K.; otherwise it is not.

Wiring connections to projection cutout should be made ahead of the switch and the switch should always be open when tests are being made. The projectors should be permanently grounded by a ground wire and this ground wire should be left connected during the making of the tests.

TROUBLE LAMP.—A "trouble lamp" should of course be installed, and the best way to do this is to place in some convenient location a permanent socket containing a plug to which sufficient cord is attached to reach any part of the room. At the extremity of this cord should be a lamp socket and an incandescent lamp of suitable power, covered by a wire guard to prevent breakage.

PROJECTOR CIRCUITS.—As has already been said, Page 302, the projector circuits should be carried under the floor to a point immediately under each projector lamp house, but where circumstances for any reason prevent this, or make it difficult, then the projector circuit may be carried above the ceiling, or if that is impractical, then the projector circuit may be carried along the ceiling to a point just to the rear of the lamp house, whence the conduit may drop down to a point just above the rear end of the lamp house. There is in fact very little real objection to this latter plan, provided the lamp house be piped to the vent flue as per Page 363, so that the wires will not be subjected to the heat arising from it.

SWITCH ENCLOSURE.—It is usually required that all switches (except those of the enclosed type) and fuses be enclosed in a metal cabinet. This requirement unquestionably adds an element of safety, since there is always the chance of something falling against an unprotected switch or open fuse contacts, and causing trouble; also there is always the possibility of the projectionist himself accidentally coming into contact with unprotected switches or fuse contacts and receiving a disagreeable shock, or even a burn.

The projector switch itself must be of the "enclosed" type, i. e. enclosed in a sheet metal casing.

DOUBLE THROW CONNECTION.—It is very bad practice to connect the two projectors through a double-throw switch to the center contacts of which the supply is attached, so that it is necessary to extinguish one projector lamp before the other can be lighted. This sort of connection is only permissible in cases where current is taken through a single motor generator or rectifier of such small capacity that it cannot supply both lamps, even for a limited time. Even under this condition it is very much better to wire in parallel (multiple) and "steal" the current from one lamp to the other, than to adopt the above described plan.

Where the motor generator or mercury arc rectifier is too small to allow burning both arcs together for even a limited time, or where only one economizer is used, Fig. 95 offers an excellent plan by means of which the idle lamp may be warmed and a crater burned in by means of a rheostat. By tracing the connections in Fig. 95 it will be found that with the switch in the position shown in the diagram the right

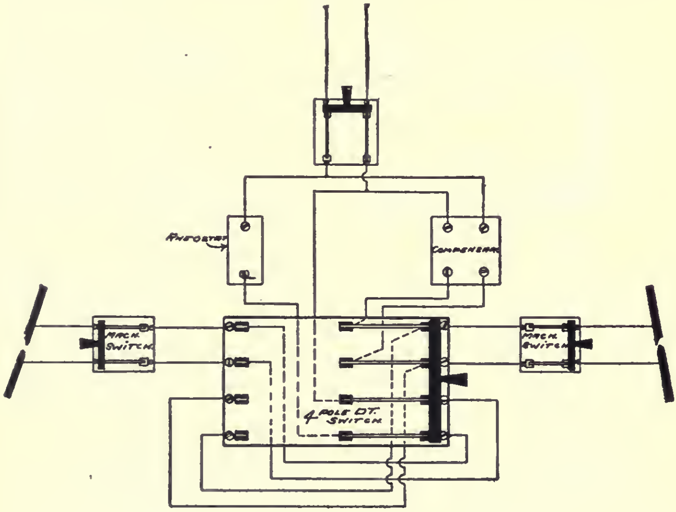


Figure 95.

hand lamp is taking current through the compensarc while the left hand lamp is taking current directly from the supply lines through the rheostat. When the four-pole switch is thrown over the same condition will prevail, except that the left hand lamp will then be taking current through the compensarc and the right hand lamp through the rheostat. The arrangement is a most excellent one under the conditions we have named, and the wiring of the diagram is sufficiently plain that any projectionist or electrician should be able to make the installation without trouble, substituting either a motor generator or a mercury arc rectifier for the compensarc, if either one of them be used.

POLARITY CHANGER.—Where the supply is taken from a small D. C. plant it sometimes occurs that when dynamos are changed the polarity changes, which requires the instant switching of your own wires to bring the positive back to the upper carbon. This may quickly be accomplished by the installation of a double-throw double-pole switch, such as is seen in Fig. 96. Throwing this switch

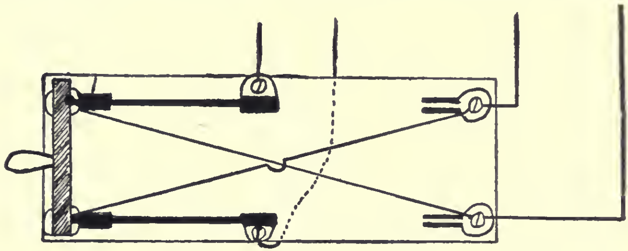


Figure 96.

over changes the polarity of the wires. The cross wires should be protected by flexible insulating tubing in addition to their own insulation.

Fig. 97 is the diagrammatic representation of a combined polarity switch and fuse changer. By throwing switch A a new set of fuses is brought into use and by throwing switch B the polarity at the arc is changed.

CONNECTING TO TWO SOURCES OF SUPPLY.—For various reasons it is frequently desirable to make connection to two separate sources of electrical supply. One may have one's own light plant, but wish, in case of accident, to be able to instantly connect to the wires of the city plant. This may be done, but details may vary widely in different cases. Suppose, for instance, we have a house plant delivering direct current at 110 volts, while the city plant produces A. C. at 110 volts; both systems two-wire. The problem then is simple.

Install a double-pole, double-throw switch, as per Fig. 98. The house plant being D-C, we shall not need nearly so much amperage from it as would be necessary for equal screen illumination with the city plant, A-C; therefore, we install two rheostats, A and C, the lower one, A, to be used with the D-C house plant. B is a double-pole single-throw knife switch which is open when D-C is in use, so as to use only rheostat A. When we change to A-C, however, we close switch B, thus cutting rheostat C in multiple with rheostat A. Rheostat C should have capacity sufficient to build the combined amperage of the two up to that necessary for good illumination of the screen. Suppose we use 35 amperes D-C. In order to secure anything like the same curtain brilliancy rheostat C must have capacity sufficient to deliver 25 amperes which, combined with the capacity of rheostat A, will give 60 amperes at the arc. But we must remember that, owing to the shorter A-C arc, hence the less arc resistance, rheostat A will deliver somewhat more current on A-C than it will on D-C, the voltage of the supply being the same in both cases. We will probably, therefore, be not far out of the way if we have rheostat C of capacity to deliver 20 amperes at the arc.

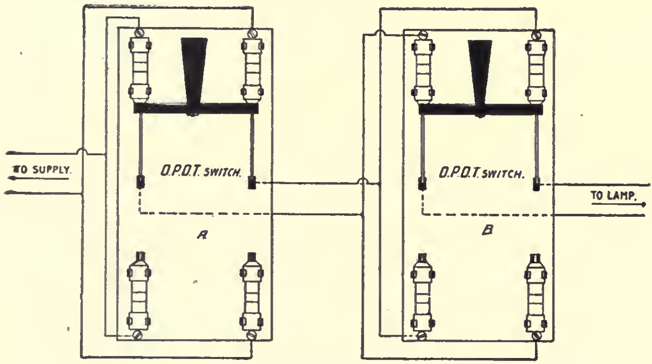


Figure 97.

We may, however, instead of this, install a transformer (economizer, inductor, compensarc, etc.), in place of rheostat C, Fig. 98, and with a triple-pole double-throw switch, wired as per Fig. 99, cut out resistance A, Fig. 98, substituting the economizer therefor. Merely throwing the switch over would then change from rheostat to transformer, and vice versa, though the transformer would be "alive" in the sense that you could get a shock from it. But this would do no harm. If you wish to "kill" the transformer entirely when using the rheostat, it may be done by installing a S. P. S. T. switch at X, Fig. 99.

Please understand there are many other switch arrangements possible. Such things may be done in many ways. Those suggested merely illustrate two possible methods. Another and still better way to cut the two rheostats in multiple, Fig. 100, is by means of a triple-pole, double-throw switch.

A careful tracing out of the connections in Fig. 100 will

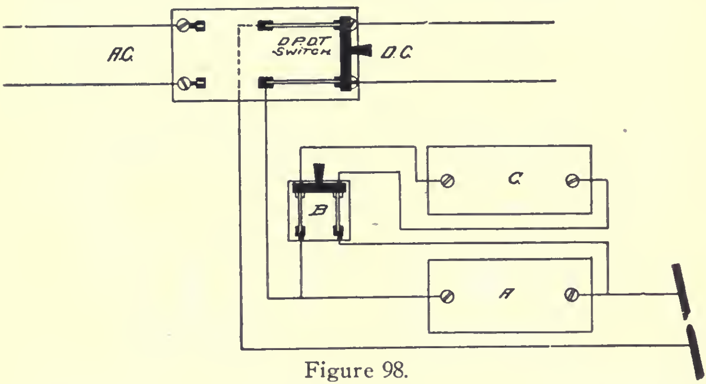


Figure 98.

show that when the switch is thrown to the A-C supply side the two rheostats are in multiple, while when the D-C side is in use only rheostat 1 is working. Should the supply voltage be higher on one system than on the other, a higher voltage rheostat could be substituted for A, Fig. 98, and rheostat C be made of such capacity that it will bring the amperage up to normal when on the lower voltage.

GROUNDS.—Grounds are perhaps the one most puzzling thing to the novice. They also very often tax the knowledge of experienced projectionists. This we believe arises partly from the fact that the term, as used, has, strictly speaking, more than one meaning. In one sense, a "ground" means a current carrying connection with the earth which offers a path through the earth to a wire of opposite polarity. When we speak of a ground in a rheostat, we however do not necessarily mean that there is any connection with the earth itself. Two coils may be "grounded" to the frame of a rheostat in such way that a part of the resistance of the rheostat is eliminated, notwithstanding the fact that the rheostat as a whole sets on an insulating shelf, and has no possible connection of any kind whatsoever with the earth. In its simplest sense the term "grounded" means that one wire of a circuit has current carrying connection with the earth, though this does not necessarily mean that there will be current leakage into the earth. This latter will only occur when the ground offers an electric path to a wire of opposite polarity which is attached to the same generator.

EDISON SYSTEM GROUNDED.—The neutral wire of all Edison 3-wire systems is permanently grounded to earth. This is a true ground, and if an accidental ground occurs on either of the other wires of the system there may be and probably will be current leakage.

Right here let us make it clear that the rather common belief that current seeks to escape from the wires into the ground is entirely wrong, except when by so doing it can find a path to a wire opposite polarity which is attached to the same generator. See Page 6. Let us also further emphasize the fact that:

Current generated by one dynamo has absolutely no affinity for the opposite polarity of another dynamo except when

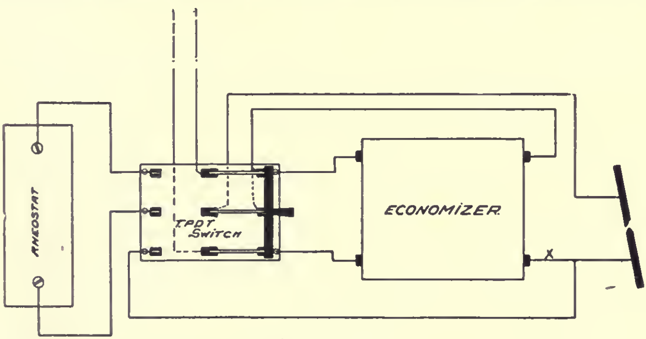


Figure 99.

the two generators be electrically connected, as in the 3-wire system, in which case they are to all intents and purposes one machine.

Fig. 101 is a diagrammatic representation of a true ground. A is a circuit attached to generator G. B and D are subsidiary circuits branching from it, and C is a circuit attached to another generator Y. Now let us assume a ground to exist at point Z in the lower or negative carbon arm of arc lamp F on circuit D, and that a ground develops at X on the positive of subsidiary circuit B. Let us also assume that a ground exists at X on the negative of circuit C attached to generator Y. The result of all this would be that although the ground at X on circuit C is considerably nearer the ground at X on circuit B than is the ground at Z, and that quite possibly it would therefore offer decidedly

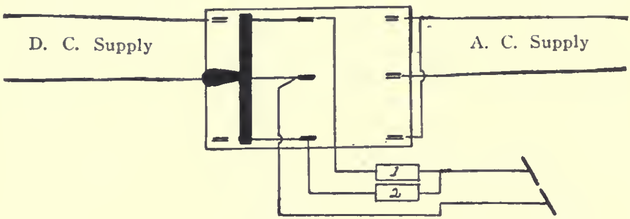


Figure 100.

less resistance to the passage of current, the current nevertheless pays no attention to the ground at X on circuit G but travels through the earth to point Z where it can enter a negative wire attached to its own generator. On the other hand should a ground develop in rheostat E, which is on the positive of circuit D, and a ground develop at O in circuit A the current would enter the earth, follow the dotted line and enter the negative wire at O.

Let it be understood, however, that it does not necessarily follow that because two wires of opposite polarity have current carrying connection with the earth there will be current leakage, because the ground thus established may have such high resistance that ordinary voltage will not overcome it. In reaching the earth through a ground the current will often follow a devious path through water or gas pipes or electric conduits, the latter being always grounded.

The grounding of the 3-wire system is a puzzle to many. There are two kinds of 3-wire systems, viz.: The Edison system, in which the neutral is always thoroughly grounded, both at the generator and at other points along the line; and the 3-wire system in which the whole system is insulated from the earth. The latter system is only used by small isolated plants.

The reason for grounding the neutral in the Edison system is to prevent any possibility of the conduit in buildings becoming charged at 220 volts, or, to put it in electrical terms, to limit the difference in potential between any wire in the conduit system in buildings to 110 volts.

With the Edison 3-wire system, the test lamp will not show a light from neutral to ground because the wire is already grounded, hence if the carbon arm of your projector lamp which is attached to a neutral wire of an Edison system be grounded there will be no effect unless your rheostat be on the neutral wire, in which case the fuses may blow when the arc is struck. This latter is by reason of the fact that the striking of the arc completes the circuit through the ground, as indicated in Fig. 101, which might eliminate the rheostatic resistance, leaving only the resistance of the arc and such resistance as the ground may offer, which may be more or less than was offered by the rheostat itself. It might incidentally be said that theoretically it would be quite possible when using an Edison 3-wire system and rheostatic resistance to locate the resistance on the outside wire, remove the insulation from the carbon arm to which the neutral is attached, disconnect it from the wire and

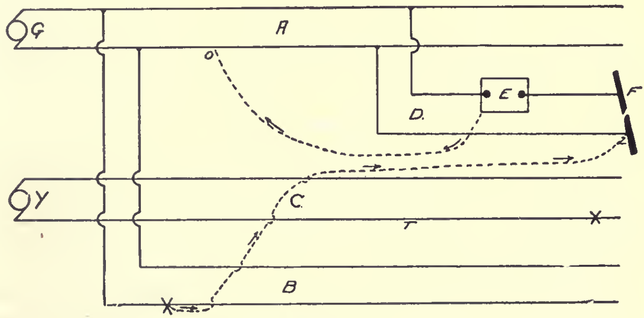


Figure 101.

thoroughly ground the carbon arm, whereupon the arc would operate the same as though it was connected to the neutral. The above, however, is not a practical thing to do because of the fact that any ground which might be established would in all human probability offer very much higher resistance than would be offered by the copper wire, also the resistance offered would probably not be constant, but variable and unstable.

TESTING FOR GROUNDS.—Grounds may be tested for in a number of ways. A battery and buzzer or a magneto bell may be used. It is even possible to test for ground with just a plain copper wire, depending upon the spark resultant upon making and breaking contact to disclose the passage of current; but the latter plan is not recommended, since if the ground be a heavy one a heavy flash and blowing of fuses might occur.

The practical testing tool for the projectionist is, however, the test lamp, a permanent form of which is illustrated in Fig. 102. For two wire circuits a test lamp consists of a socket containing an incandescent lamp of the voltage of the system, with two wires attached thereto. These wires

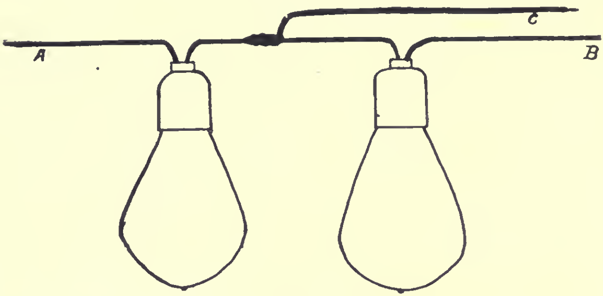


Figure 102.

may be of any convenient size and length. Fig. 102 illustrates a test lamp to be used either with a 2-wire or a 3-wire system, wires A-B being used for testing across the two outside wires, and wires A-C for testing from neutral to either outside wire.

Taking Fig. 101 for example, and considering lamp F on circuit D as a projector arc lamp, if we disconnect the projector ground wire, thus insulating the projector from the ground, and then touch one wire of the test lamp to the **upper** carbon and the other to the frame of the lamp back of the insulation of the lower carbon arm, and the test lamp lights; or there is a spark when the wire is rubbed along the metal of the lamp frame, we know there is a ground in the **lower** carbon arm. The arc must be not burning and the carbons of the lamp must of course be separated when the test is made.

In using the permanent test lamp described in Fig. 93 we would disconnect the projector ground wire and touch the wire of the permanent test lamp to the lamp frame. If there is a spark as the wire is rubbed along the metal, or if the test lamp lights (sometimes a ground may be existent but of such high resistance that there will not be sufficient current passing to heat the filament of the test lamp red. In this event the ground is detected by the spark at the end of the wire) we know one or the other of the carbon arms are grounded. If it is an Edison 3-wire system we know it is the arm not connected to the neutral. If it is not an Edison 3-wire system then we have only to disconnect one of the wires of the lamp to determine which arm it is. If there is no further evidence of a ground we know the trouble is in the arm from which the wire has been disconnected. If the test lamp still lights, or there is still a spark we know the trouble is in the carbon arm which is still "alive."

Always disconnect the ground wire of the projector before attempting to test your lamp for grounds, except when using the Auerbach method.

TESTING WITH BATTERY.—Another simple method of testing the arc lamp for grounds is to use a dry battery. No bell is necessary. Just connect two wires to the battery and, with the projector table switch open, touch one wire to the lamp frame and the other to first one and then the other carbon arm. If there is a ground there will be a spark, but this test should be made in a darkened room, because the spark may be faint, due to the low voltage of the battery. As a matter of fact the battery test is not very reliable because a high resistance ground which might let current through when subjected to 110 volt pressure might not show at all with the battery test.

The magneto test is of course the best of all, but the projectionist can hardly afford to add a high-priced magneto to his tool kit. The magneto test is best by reason of the fact that the magneto produces voltage very much higher than that of any projection circuit. To test the arc lamp with a magneto you have only to open the projector table switch and connect one of the magneto wires to the lamp frame and touch the other alternately to the two carbon arms. If there is a ground in the insulation the bell will ring.

With the insulated 3-wire system the test lamp acts exactly the same as it does with the plain 2-wire system.

LOCATING GROUNDED RHEOSTAT COILS.—The locating of a grounded rheostat coil or grid is a very puzzling thing to the novice, as well as to many projectionists. It really is, however, a very simple matter.

In Fig. 103 we have the diagrammatic representation of a rheostat, in which A M C D, etc., are the coils or grids, one of which, E, is "grounded to the frame" at X, meaning by this that it has current carrying connection with the frame at that point. Assuming that we wish to test the rheostat,

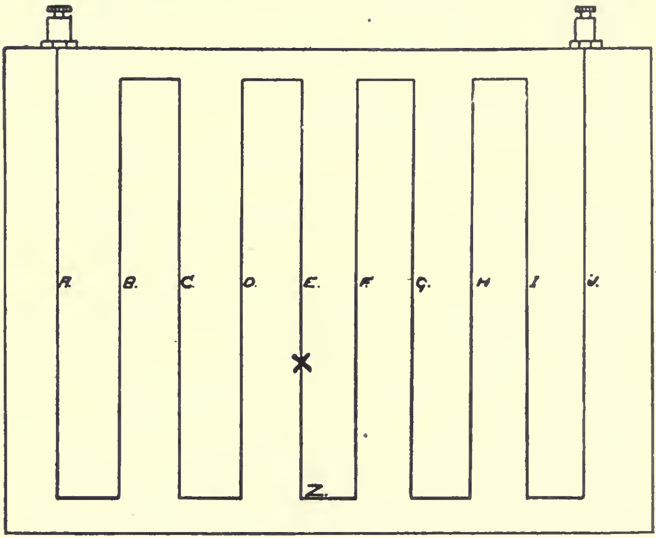


Figure 103.

Fig. 103, to find out whether or not it is in good order; using a magneto, or a bell and battery, first touch the rheostat binding posts with the two leads from the bell and battery, or the magneto. If the bell rings it indicates that the circuit is complete; that is to say, no coil is broken or disconnected. Next touch one binding post (either one) and the outer casing of the frame of the rheostat. If you get no ring, then the rheostat may be considered as in good order, except that, as before indicated, there may be trouble which would develop when the rheostat is subjected to full voltage which would not be indicated by the low voltage of a battery, but which would be discovered by a magneto, and except for one thing which cannot be located with a bell, a magneto or test lamp, viz.: two coils being sagged together, which would eliminate a part of the resistance of the rheostat without breaking the circuit.

This latter could only be determined by a physical examination of the rheostat, or by observation when it was in actual use, in which latter event the point of contact between the two coils or grids might, and probably would be, heated sufficiently to become visible.

Rheostats may be tested with a test lamp in a number of ways. First, assuming the rheostat as a whole to rest upon insulating material, with the current on, attach your test lamp to the frame of the rheostat and to a wire of opposite polarity. If there is a spark at the point of contact, or if the test lamp lights, the coils or grids are grounded to the frame at some point, and the exact point may be located as hereinafter described.

Another method would be to disconnect the wire leading from the rheostat binding post, connecting the same to one of the test lamp leads then, first having "frozen" the carbons of the arc lamp, touch the rheostat frame with the other test lamp lead. If the test lamp lights, or if there is a spark at the point of contact, then the coils or grids of the rheostat are grounded to the frame at some point. If, however, there is no spark, or if the test lamp does not light, then the coils and grids are insulated from the frame.

Still another way, again assuming the rheostat as a whole to rest on insulating material, is to disconnect one of the wires from the rheostat binding post and, with the carbons of the arc lamp "frozen" and the projector table switch closed, touch the disconnected wire end to the frame of the rheostat. If you get a spark there is a ground. This latter method of course amounts in effect the same as the one previously described, except where the test lamp is interposed between the wire and the frame its resistance limits the current flow and there is no danger of blowing fuses, which might occur if the last test named were applied.

Suppose we have applied one of the before described tests and find there is a ground in the rheostat, indicating that one or more of the coils or grids has current carrying connection with the rheostat frame. How are we to discover the particular coil or grid at fault? That is the point which puzzles so many, but it is a point which becomes very simple when we examine it in the light of common sense.

First disconnect the wire leading from the rheostat to the arc lamp, leaving only the wire connected which leads from the source of electrical supply to the rheostat. Now, first having removed the casing of the rheostat, connect one of your test lamp wires to the frame of the rheostat and the other test lamp wire to a wire of opposite polarity. Assuming we have disconnected the wire from the left-hand binding post, in Fig. 103, we will disconnect coil or grid A, and if the test lamp still burns, or if there is still a spark when its contact with the rheostat frame is made and broken, we know the trouble is not in A, since the ground still exists. We therefore connect B C D and E. When coil or grid E has been disconnected the test lamp goes out or the spark ceases, hence we know the trouble lies in that coil or grid. The trouble in coil or grid E may be due to direct connection with the frame caused by sagging, or it may be and probably is due to a fault in the insulation.

If a rheostat consists of two banks of coils or grids, considerable labor can be saved by disconnecting one bank from the other, and then testing each as a whole to find out which half the ground is in. It is then only necessary to disconnect the individual coils or grids of the defective side.

GROUNDING THE PROJECTOR.—It is always advisable that the projector lamp house, mechanism and frame be permanently grounded to the metal of the projection room, if any there be, and then the whole may or may not be thoroughly grounded permanently to a water pipe.

The reason for grounding the projector to the projection room metal work is that if the projector be insulated from the metal of the projection room and the lamp should become grounded to the metal of the lamp house it would charge the whole mechanism with voltage, and, should the projectionist in the act of putting a reel in the magazine touch the reel to the magazine and the metal of the projection room there would be a spark which might set fire to the film.

There is no real necessity for the grounding of the metal of the projection room as a whole. It may or may not be done, as best suits the idea of the individual.

EFFECT OF GROUNDING.—The effect of grounding the projector lamp is that current is wasted and the brilliancy of the light is itself likely to be affected, particularly if the ground be a heavy one, since a portion of the current is escaping through the shunt circuit produced by the ground, instead of passing through the carbons and producing light.

Projectionists will do well to test their lamps for ground every day. It only takes a few moments and is well worth the trouble.

One prolific source of current leakage in the arc lamp is due to carbon dust settling across the insulation of the carbon jaws. This is not so likely to happen in the modern type of lamp, but with the old lamps it was a constant source of annoyance. However, the projectionist will do well to dust off the top of his carbon arms, particularly the insulation, every day before he starts the run.

IF YOU DO BETTER WORK WHEN THE BOSS IS WATCHING, YOU ARE A VERY POOR MAN TO HAVE ON THE PAY ROLL.

The Projector

THE LAMP HOUSE OF THE PROJECTOR has grown from a little sheet iron affair about six inches wide by twelve inches long and twelve inches high, to an imposing structure of very ample dimensions. It is well that it is so, because a roomy, well constructed, well ventilated lamp house is essential to high-class work in these days of high amperage and a brilliantly lighted screen.

In the early days when it was the exception to use in excess of 25 amperes for projection, and 30 was about the limit, very little attention was paid to the housing of the lamp. The main object was to provide a holder for the condenser and to confine at least a part of the light. With the modern projection arc, in some instances using as high as 120 amperes, the tremendous heat generated has compelled close attention to lamp house ventilation and has compelled the increase in size before mentioned, while the advance in projection optics and the tendency to breakage of lenses through the heat of high power arcs has obliged manufacturers to give close attention to the condenser mount, all of which has resulted in a vastly improved and very efficient lamp house.

LAMP HOUSE VENTILATION.—The ventilation of the lamp house is of extreme importance, especially where high amperage is used, since unless there be ample air circulation the temperature inside it will reach a very high degree, which will automatically operate to (a) reduce the capacity of the carbons, (b) injure the wires on the interior of the lamp house, as well as to some extent the metal of the carbon jaws themselves, (c) set up a tendency to abnormal condenser breakage and (d) through heat radiation make it both uncomfortable and unhealthful for the projectionist in southern climates, or during warm weather in more northern latitudes.

One cause for poor lamp house ventilation is chargeable to what can be termed nothing else than pure unadulterated carelessness or laziness on the part of the projectionist, who allows the vent screens to become clogged either almost or quite solid with ash and dirt.

In the process of volatilization water glass, which forms the binder of the core of carbons, produces a gray colored ash which is very light in weight. It is this ash which forms the white coating found at the top of and on the interior walls of the lamp house. It is carried upward by the draft and gradually chokes the perforated metal used for vent screens in the old style lamp house. Unless this deposit be frequently removed and the screens thoroughly cleaned, all ventilation will be stopped in a comparatively short time. It is the failure to keep these screens free from this accumulation which we have charged to carelessness or laziness on the part of the projectionist. We do not like to use such harsh terms, but the fact remains that this condition is responsible in altogether too many instances where condenser breakage is complained of.

BEST METHOD OF VENTILATION.—The best method of ventilation is illustrated in Fig. 104, in which a three or four-inch sheet metal pipe is attached to the top of the lamp house, and is either carried to the open air or connected to the vent flue.

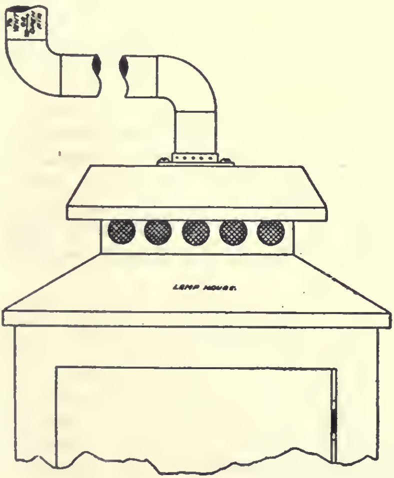


Figure 104.

Some years ago the author secured the consent of the leading projector manufacturers to the placing in the top of their lamp house an opening to which such a pipe could be attached. The installation of a vent pipe of this kind serves to carry away very much of the heat of the arc, hence reduces the liability to condenser breakage and renders the position of the projectionist far more tolerable during the hot summer months. It has the hearty endorsement and approval of the projection department of Moving Picture World and the author of this book. The author would earnestly recommend its installation in all projection rooms, on the score of health if there were no other reasons; because the pipe carries away all fumes of volatilizing carbons which are not especially healthful. In installing the pipe, however, remember that only a part of its purpose is served if you merely run a short piece of pipe up a foot or so above the lamp house. This ventilates the lamp house all right, but it does not remove from the room either the heat of the arc nor the gases formed by the volatilizing of carbon; also it would not be approved by the authorities in some cities.

Run the pipe out to the open air, into the projection room vent flue or into the exhaust pipe if the projection room is connected with the house ventilation system.

It is not necessary that this pipe be capped with a screen if this is done, because in any event it would not be less than five or six feet long, and by no stretch of even the wildest imagination would a spark from an electric arc carry such a distance.

SWING JOINT IN VENT PIPE.—If it is necessary to swing the lamp house over to a stereopticon lens it can be readily done by providing a combined swing and slip joint in the lamp house vent pipe.

Lack of ample ventilation in the lamp house causes exhibitors as a whole a large sum in condenser breakage every day. While no figures are available we believe this item will in all probability amount to as much as $500 a day in the United States and Canada alone, meaning that that value in condenser lenses probably is destroyed which would not be destroyed if lamp houses all had ample ventilation.

PROJECTING CRATER IMAGE.—As has already been pointed out, from many viewpoints, it is desirable to project an image of the crater to the wall, ceiling, floor or to some other place where it will be constantly in view of the projectionists. A crater projector designed to be attached to the lamp house door may be purchased from almost any dealer in supplies, or one may be made as per directions given under "Crater Angle," Page 405.

LIGHTING INTERIOR OF LAMP HOUSE.—It would be a very simple matter to place a small porcelain lamp receptacle in the bottom of the lamp house, at the right hand, rear corner. From one side run a wire to one side of any convenient incandescent circuit. From the other side attach to the other side of the circuit through a spring-switch, made as per Fig. 105, attached to the right hand lamp house wall in such way that a piece of fibre fastened to the lamp house door will shove the switch open, thus putting out the light, when the lamp house door is closed.

By the use of a low C-P lamp the interior of the lamp house is thus automatically illuminated when one opens the door to re-set the carbons, etc.

CONDENSER HOLDER.—It is only of late years that any particular attention has been paid to the condenser holder, but now all the recognized professional projectors have a more or less efficient arrangement both for holding the lenses, and for spacing them properly with relation to their distance from each other. A condenser holder which has no provision by means of which the projectionist may alter the spacing of the lenses by means of an adjusting screw located outside the lamp house and casing is not a good holder.

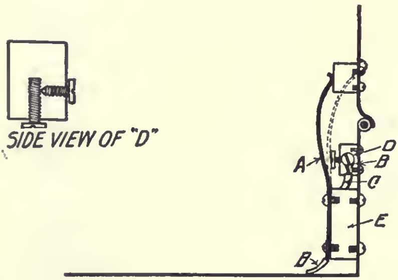


Figure 105.

WHY CONDENSERS BREAK.—Condenser lenses break because one part of the lens, the edge, is thin, and another part, the center, is thick, hence when subjected to heat the thin edge increases in temperature very rapidly and expands very rapidly as compared to its thick center. Also when the arc is shut off the thin edge contracts very rapidly as compared to the thick center.

We believe it was W. G. Woods, a San Francisco projectionist, who first recognized this proposition and undertook to provide a means for equalizing the contraction and expansion as between the thin edge and the thick center of the condenser lenses. The idea, which has later been adopted in one form or another by all manufacturers of professional projectors, was to firmly clamp the thin edge of the lens in a metal retainer, the amount and kind of metal of which was carefully calculated with a view of its temperature rising as nearly as possible equally with the temperature of the thick center of the lens, and since the thin edge would be clamped in this metal ring, radiation would prevent it from heating faster than the metal holder, and the whole lens would thus be brought up to temperature

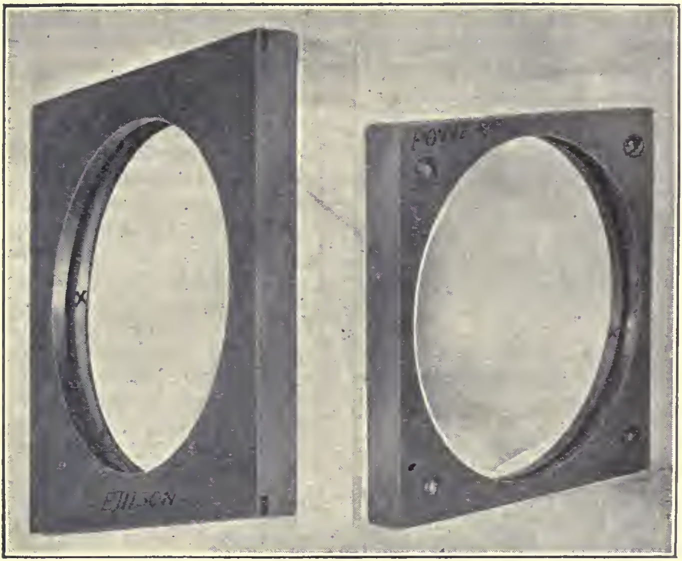


Figure 106.

evenly, and by reversal of the process would lose its temperature evenly when the arc is shut off.

The first of these holders, known as the "Elbert Holder," is shown in Fig. 106. It was the holder designed for the Powers projector by Mr. Woods, who also designed holders for the Simplex and the Motiograph. These holders are, so far as we know, no longer marketed.

PREDDY HOLDER.—Walter Preddy of San Francisco still makes the Preddy condenser holder illustrated in Fig. 107.

This holder is excellent for use with old style lamp houses which are not equipped with the modern condenser holders now put out with all professional projectors. They are moderate in price and may be had from any first-class supply dealer, or from Walter Preddy, San Francisco, California. Their method of mounting is shown at the right in Fig. 107.

REQUIREMENTS OF CONDENSER HOLDER.—The requirements of the modern condenser holder are that the metal of the holder shall have good, even contact with lenses, since unevenness of contact between the metal and

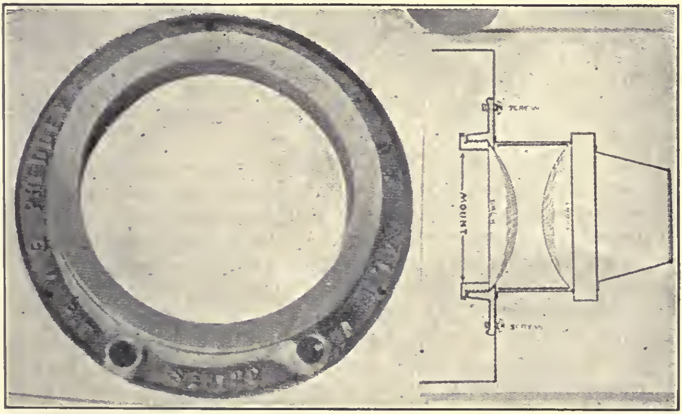


Figure 107.

the glass produces uneven radiation, with uneven expansion and contraction, and consequent tendency to breakage. It must grasp the lens firmly enough to insure good contact between the metal and the glass, with consequent evenness of radiation, but at the same time not in any way binding the lens, because the ratio of expansion of glass and metal is different, and if the lens be bound tightly in the holder, expansion will exert such a tremendous force that breakage will almost inevitably occur. The metal in which the lens rests must be so calculated with regard to its amount that the purposes of a heat and cold reservoir as hereinbefore set forth will be as nearly as possible perfectly served. The holder must be so constructed that by means of an adjusting screw located outside the lamp house the projectionist may alter the distance between the two lens holders in order to accommodate the difference in thickness of lenses of different focal length. The holder must be so constructed that while it is held locked securely in place, the lenses may still be made immediately and easily accessible to the projectionist for removal and replacement, always remembering that removal and replacement in a minimum of time may be necessary when the lens to be removed is very hot, and a hot lens is a reasonably difficult thing to handle.

POSITION OF CONDENSER HOLDER.—The modern and generally accepted practice is to place the condenser holder inside the lamp house, where the lenses are subjected to a rather high but comparatively even temperature, rather than to the uncertain and possibly rather sudden changing temperature of the condenser casing located outside the lamp house.

SHUTTER FOR CONDENSER.—Some modern lamp houses are provided with an interior douser, which comes down between the arc and the collector lens, rather than in front of the converging lens. This is, we believe, good practice, since it to a considerable extent protects the collector lens from sudden changes of temperature when the lamp house door is opened while the lenses are hot. Such a shutter may be installed by the projectionist himself, and may be so made that it will be lowered by the act of opening the lamp house door and raised by the act of closing it, so that the lens will always be protected when the lamp house door is open. In order to do this a shutter, preferably made of quarter-inch asbestos millboard, must be installed in grooves, the latter so supported that when the shutter rests on the bottom stop it will cover the interior surface of the condenser. From the top of this shutter a light chain may be run up and out through a small hole drilled in the lamp house roof or wall, and after passing over a pulley be attached to an arm riveted to the lamp house door in such way that opening the door will drop the shutter, while closing the door will pull it up. We believe this description is sufficiently clear to serve the purpose without the aid of an illustration.

KEEP THE LAMP HOUSE CLEAN.—The careful, competent projectionist will keep his lamp house scrupulously clean. It is not creditable to the projectionist to find dirt, dust, pieces of broken carbons, carbon stubs, etcetera, littering the floor of the lamp house. It doesn't impress one with the idea that the man in charge is a good workman, because it is not a workmanlike way of doing things.

At least once a week the projectionist should, using a good hand bellows, blow the carbon ash out of the vent screens down into the lamp house, whence it can be removed. Of course if the lamp house be equipped with a vent pipe, as before described, this will not be necessary, though the carbon ash should be swept out of the top of the lamp house once a week, merely as a matter of cleanliness. The removal of this ash is rather an unpleasant job, because being very light in weight it is apt to fly all over everything. Our own way of doing the thing used to be to take the lamp house off once a week, take it outside and clean it thoroughly, but this is hardly practical with large, heavy modern lamp houses. By blowing the dust down into the lamp house first, however, and by careful work thereafter, very little, if any, of it should escape into the room. Lamp houses should have an opening at the bottom through which dust and dirt can be swept. The removal of dirt from the bottom of a lamp house not thus equipped is a tedious and a decidedly unpleasant task.

Many projectionists who are using old type lamp houses will find that when the lamp has the desired angle, the lower carbon jaw will come into contact with the front wall of the lamp house, thus charging the whole projector with EMF. Where this occurs the projectionist should secure a thin piece of asbestos millboard (sheet asbestos will do), and attach it to the front wall of the lamp house in such way that it will come between the lower carbon jaw and the metal of the lamp house.

If the lamp house is of the old, unlined, narrow type it is an excellent plan to rivet 1/8th-inch asbestos millboard, or sheet asbestos, to the left hand wall or door opposite the binding posts of the lamp, since many annoying grounds are caused by a stray strand or strands of the lamp leads protruding and making electrical contact with the lamp house wall.

THE LAMP.—The projector arc lamp is a most important feature in the production of good projection light. It is in fact impossible to secure consistently even screen illumination with a poor, badly worn, loose, "wabbly" or dry lamp. Theatre managers who oblige their projectionists to work with an old style arc lamp are doing a very foolish thing, and one which cannot but result in inefficient work on the screen.

To be in accord with modern practice a projector lamp must have an adjustment for feeding the carbons; an adjustment by means of which one or the other of the carbon jaw may be moved sidewise; an adjustment by means of which the whole lamp may be moved forward and back; an adjustment by means of which the whole lamp may be raised vertically up or down; an adjustment by means of which one or the other, preferably the lower, carbon jaw may be moved forward or back with relation to the other jaw; an adjustment by means of which the whole lamp may be moved sidewise; and an adjustment for altering the angle of the lamp as a whole. All these adjustments, except the last named, must be available to the projectionist from the exterior of the lamp house. In addition to this many projectionists demand that there be means provided for the tilting of the carbon jaws to accommodate the "jack-knife" carbon set, but the author believes that just as good, if not better results would be had if this last adjustment were entirely omitted.

INSULATION.—The carbon jaws must of course be insulated from the carbon arm, the jaws being the only part of the lamp electrically charged. This insulation is composed of sheets of mica, and there is of course an insulating "barrel" of mica around the screws or bolts which clamp the jaw to the lamp arm. Projectionists should be very cautious about loosening the joint between carbon arm and jaw, because if the insulation around the bolts or screws be injured or destroyed considerable trouble is likely to be experienced in replacing it.

CARBON DUST GROUNDS.—The projectionist should be careful to keep the lamp free from carbon dust, particularly around the insulation, since it is quite possible to form a current-carrying ground through carbon dust settling on the top of the surface of the carbon jaws and arms. Before projector manufacturers adopted the practice of raising the edge of the mica insulation above the surface of the metal at the top of the carbon arm and jaw, carbon dust formed a prolific source of grounds in the lamp. This can no longer occur unless the projectionist is careless enough to allow a very considerable amount of dust to accumulate.

CARBON CLAMPS.—It is of very great importance that the carbon jaw make as nearly as possible perfect electrical contact with the carbon, since otherwise heat will be generated; also there will be more or less arcing between the carbon and the metal, which will tend to gradually roughen the jaw by forming pit-holes in its surface, thus setting up a very bad condition indeed. Any heat caused by poor contact between the metal and the carbon increases tendency to penciling of the carbon, because it adds to the heat of the arc the heat formed by the poor contact. A good plan for keeping the contact in good condition is to wrap a round piece of wood about the diameter of the carbons being used with No. 00 sand paper, or very fine emery paper or cloth, and **every day** before starting the run clamp this lightly into the carbon jaws and give it a few twists. This will remove any scale or other thing adhering to the carbon jaws which might tend to increase the resistance between the metal and the carbon. The cleaner above described is easily made by cutting sheets of sand or emery paper into strips an inch or so wide, and winding them spirally around the cleaning rod tightly, fastening the upper end with a thumb tack such as draughtsmen use.

LAMP LUBRICATION is an exceedingly important thing. Projectionists should make it their practice to lubricate their lamp thoroughly at stated periods. Twice a year all screws should be removed from the lamp, dipped in kerosene and then into a box of powdered graphite, the oil merely being intended as a binder to hold the graphite to the screw until it can be replaced. Moving parts should be lubricated by rubbing them with a cloth wet with kerosene and then with graphite. If kerosene is not available lubricating oil may be used as a binder for the graphite, but it must be remembered that the oil is not intended as a lubricant, but merely as a medium to hold the graphite to the metal until it is thoroughly coated. The graphite itself is the lubricant, graphite being in itself a high-grade lubricant and one which is impervious to the action of heat at ordinary temperature. In reassembling the lamp, remember that the greater the amount of graphite adhering to screws and moving parts the better. If you have never done this you will be astonished at what a difference it will make in the handling of the lamp.

Make it your invariable practice to remove the carbon clamp screws every day if the run be a twelve-hour one, or

in any event frequently, and lubricate them with graphite as above set forth. Do this and you will not need to twist up the screws with a plier. In fact, if you have been using unlubricated carbon clamp screws you will be very likely to crush the first few carbons you put in.

ASBESTOS WIRE LAMP LEADS.—The asbestos wire lamp leads are a thing concerning which the projectionist must use care and intelligence, else he will have heavy loss by reason of their high resistance.

ARC CONTROLLERS.—There are now on the market several arc controllers designed to automatically feed the carbons. The use of these controllers cannot be too highly recommended, since they maintain an absolutely steady arc length, hence an absolutely steady screen illumination, always of course provided they are proprely adjusted and handled by the projectionist.

The hand-fed lamp never has and never will give as steady screen illumination as that provided by a good arc controller. The principal upon which most arc controllers operate is as follows:

Every change of arc length means a change in arc voltage. When the arc is burning with a given carbon separation there is a certain difference of potential between the carbons called "arc voltage." As the carbons burn away the distance between their tips is of course increased, which means that the resistance of the arc is increased, hence a higher voltage is necessary to force the current across the gap. In other words added distance between the carbon tips raises the arc voltage automatically. Automatic arc controllers make use of this fact and depend upon it for their action. When the carbon burns away sufficiently to alter the arc voltage by a very small amount, a mechanism is engaged which feeds the carbons together until the normal arc voltage is reestablished, whereupon the mechanism automatically ceases to function until the arc voltage again rises sufficiently to re-energize it.

A good arc controller operates on such slight change in carbon separation distance that the feeding of the carbons is well nigh imperceptible, hence a practically uniform distance of carbon separation is automatically maintained. We will present herewith, in proper place, an illustration of some arc controllers now on the market, at the same time describing their characteristics as set forth by their manufacturer. We do not deem it advisable to undertake the giving of greatly detailed instructions on this class of equipment, because such instructions should accompany them when they are installed, and there is constant liability to slight changes in construction which would greatly lessen the value of detailed instructions were we to provide them. See Page 559.

KNOWLEDGE IS POWER.

Carbons

LIGHT is the foundation of projection, and light for projection purposes depends to a very great extent for its steadiness, its brilliancy and tone, upon the arc lamp electrodes (carbons), since practically the entire available illumination is produced by the incandescence of the floor of the "crater" formed by the current action on the tip of one (the positive) of the carbons if D-C is used, because one carbon is then constantly positive, or of both carbons if A-C is used at the arc, since then both carbons are alternately positive and negative.

Each form of arc lighting requires the use of carbons having different physical characteristics. For projection work, where the light must be, to all intents and purposes, absolutely steady in value, not too harsh in tone, and very brilliant, a special grade of carbon is required, which must be very free from impurities, hard spots and other imperfections. Such carbons call for very great care in manufacture, and a high degree of engineering skill in the preparation of formulas.

HOW THEY ARE MADE.—The procedure of American carbon manufacturers in the making of projection carbons is as follows: The basis of projection carbon is lampblack, the purest form of carbon known. The ordinary lampblack used in the manufacture of other types of lighting carbons contains far too much ash to be satisfactory, therefore a specially selected black is employed. Even this material contains considerable volatile matter, which is driven off by calcination at a high temperature. This calcined material is known as "carbon flour," and is so pure that it is less than one-twentieth of 1 per cent. (.0005) ash, and contains little or no volatile matter. A high grade binder is then added to this flour, after which it is machine-mixed into a stiff mass, in a fashion very similar to that employed in kneading bread dough. This mass is then fed into the cylinders of hydraulic presses, which force it through suitable dies under very heavy pressure. As it comes from the presses the carbon is received upon grooved boards, made for the purpose. It is now in the form of rods. Carbons which are to be cored are forced with a central hole throughout their length, formed by having a steel pin fixed in the center of the hole in the die. At the end of the process just described the carbons are ready for baking. The form of the binder contained in the green carbon must be changed by driving off the volatile matter therein contained and depositing the residue throughout the electrode in the form of pure carbon. Inasmuch as the quality of the finished carbon depends to a large extent upon the method and temperature of the baking, this is one of the most important operations in its manufacture. The green carbons are first packed in special cylinders, to keep them from becoming crooked and to protect them from injury. They are then placed in gas fired furnaces, specially designed to secure uniform heating, from which air is excluded during the process of baking. The total operation of packing, baking, cooling and unpacking consumes from three weeks to a month.

After removal from the furnace the carbons are cut to proper length and sorted for straightness. Owing to variation in shrinkage during the baking process, some deviation from perfect straightness must be expected. The solid and hollow carbons are now separated. The former are taken directly to the pointing machine, after which they are ready for shipment; the latter go to the coring department. Here the central hole in the carbon is filled with the core material, which is a non-flaming, arc-supporting substance. The core material is mixed into a paste with water glass, a soluble alkaline silicate which becomes solid when dried. It is then forced into the hole, after which the carbons are rebaked for a short time at a comparatively low temperature in order to solidify the cores, which operation completes the process of manufacture.

PURPOSE OF THE CORE.—In order to understand the reason why it is necessary to place a core in carbons used for the positive electrode of a projection arc lamp, we must first understand a few of the whys and wherefores of the arc itself.

One may close the projector table switch, thus charging the carbons with EMF, and bring the carbon tips within 1/64th of an inch of each other without results of any kind. So long as there is an air gap between the carbons, no matter how small it may be, neither 110 nor 220 volt current will jump the space. Yet when the carbon tips are brought into actual physical contact with each other, and current flow is thus started, the carbons may be separated and the current will continue to flow, even after the distance of separation has increased to as much as three-eighths or half an inch, and under some circumstances even a very much greater distance. The novice usually is puzzled to account for this phenomenon, the explanation of which is simple.

Current of the voltage used for projection will not jump an air gap of any width at all, but when the carbons are brought into contact and separated, at the instant of separation the action of the current heats the carbon particles to the point of volatilization, and in the process of volatilization a gas is formed which to considerable extent is a conductor of electricity. From the instant the carbons are separated until they are separated so far that the resistance of the gas stream is too high to allow of the EMF forcing the current across the gap, this gas exists between the carbon tips, and furnishes a conductor for the current.

With this in mind let us examine into the reason for the placing of the core in the positive carbon. Electric current always seeks the path of least resistance, and where several paths are available a very slight change in resistance may alter the path of the current. Were we to attempt to use a solid positive carbon a crater would be formed the same as with a cored carbon, but since it would be utterly impossible to secure a carbon mass which would always have the path of least resistance in one spot, the center of the crater, the main flow of the current would, seeking the path of least resistance, move around over the face of the crater wherever at any given instant of time the least resistance was offered to its passage, which of course, since the light for projection must be absolutely steady, would not do at all.

At the incandescent crater floor the core supplies a far greater volume of arc supporting gas than does the material composing the surrounding shell, or wall of the carbon, hence the current, seeking the path of least resistance, is led by the relatively heavier gas volume to the core of the carbon, and by the above described condition is kept there, which has the practical effect of maintaining the center of the crater at the core, with resultant steadiness of illumination at the plane of the collector lens.

The reason why only one cored carbon is necessary with direct current, and two with alternating, is that with direct current only one crater is formed, whereas with alternating current both carbons are alternately positive and negative, so that there is actually a crater on both the upper and the lower carbon.

SOLID VERSUS CORED.—The objection to the use of a solid lower negative carbon for direct current is that greater care is required in order to maintain a steady arc.

The objection to the use of a cored lower carbon with direct current is that, while it makes the work easier for the projectionist, where a hand-fed lamp is used, because of the fact that the carbons will not need such frequent feeding, this is only true by reason of the increased volume of gas emanating from the lower core, and this gas forms a sort of curtain in front of the positive crater, which materially diminishes the illumination supplied to the lens.

There are those, however, who maintain that, while this is true, the gas has the effect of softening the light tone, hence it is worth the waste involved. This is to some extent true, but we nevertheless hold there are better and more economical ways of accomplishing the softening of light tones.

In this connection there are two special negatives or lower carbons on the market which should have mention, viz.: The Silver tip, made by the National Carbon Company, and the "Hold-Ark," made by the Speer Carbon Company. These are both excellent lower carbons, though both have minor objections. The metal plated carbons to some extent, have a tendency to pit the collector lens. This is caused by the burning away of the metal coating, which is sometimes thrown upon the face of the condenser, where the incandescent metal burns a spot on the polished surface. This trouble has, however, to a large extent, been overcome by the manufacturers.

The Hold-Ark negative has a core, and while this core has a reduced gas volume, still the fact remains that it does to some extent produce gas, which forms a curtain in front of the crater as already explained.

Notwithstanding these facts, we can recommend both these negatives to projectionists as being decidedly better than either the plain solid or plain cored carbon for negative.

CARBON SIZE.—The diameter of carbons is a matter of very great importance to the projectionist who desires to do his work efficiently, and to get the greatest possible amount of projection light per watt of current consumed.

If the carbon be too small there will be "penciling" or "needling," which means the burning of the carbon tip to a more or less long, slim point. The practical effect of this, for very obvious reasons, is to reduce crater area.

If, on the other hand the carbon be too large, then it seems certain that the comparatively large mass of relatively cool carbon lying close to the floor of the crater will, at least, to some extent, operate to lower the average crater temperature, which must inevitably reduce its candle power per unit of area. It therefore follows that carbons either too small or too large for the amperage used are not efficient.

INTRINSIC BRILLIANCY OF CRATER.—In the "Electrician," Volume 32, Pages 117, 145, 169, year 1893, Blondell says that although the maximum brilliancy of the crater is independent of the current flowing in the arc, yet the average brilliancy of the incandescent portions of the crater increases, both with intensity and density of current, until the crater is well saturated. "If," he continues, "the volume of the current be suddenly altered, the intrinsic brilliancy undergoes a temporary but very appreciable variation, which may reach ten per cent, but which diminishes gradually until the dimensions of the crater are so altered as to restore the surface to the value it ought to have for the new current."

Blondell says that the heating of the crater only takes place at the surface, and that the temperature of volatilization is only reached by a very thin, superficial layer, all of which seems to make plausible our argument that a comparatively large body of relatively cool carbon near the floor of the crater would operate to decrease crater brilliancy.

In the projection department of the Moving Picture World, March 15, 1919, issue, Mr. G. F. Binkelman, of the engineering force of the Speer Carbon Company, gave a very interesting and instructive talk on carbons, from which we have extracted the following data.

The charts and diagrams were all supplied by the Speer Carbon Company, to whom we owe thanks for their being made available.

Fig. 108 is a diagrammatic representation of the carbon set used for the experiments from which the data was obtained. It will be observed that all measurements were made with an 11/32d-inch space between carbon tips—an

11/32d-inch arc length. Hold-Ark negatives were used in all tests, but two well-known makes of carbons in very general use were used for positives. The test plate was ten inches from the crater and the crater maintained at a 45 degree angle with what would be the optical axis were we dealing with a projector, lens system. The carbons were inclined 15 degrees from the perpendicular. In fact everything was as it should be for a reliable test of the matters it was sought to determine, except that the crater angle was not at its point of greatest efficiency. This would not, however, affect the value of the results, but let it be remembered that in these tests we are **not** considering the lens system at all, but merely the light given off by the projection arc crater as a whole.

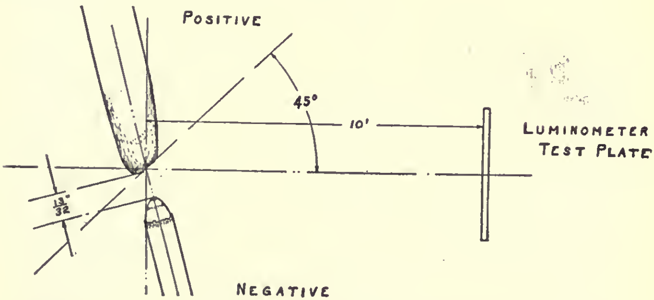


Figure 108.

(10 × 10 ft. = 100 sq. ft. = Distance squared, (Slide Constant 11.5) W)

In Fig. 109 we have curves showing the relation of candle power to amperage; it will be observed that for a given size carbon the increase in candle power is exactly proportional to increase in amperage. In other words, the curve is a straight line. It will also be observed that at any given current strength less than the capacity of any of the three sizes of carbons used the candle power per ampere decreases as the diameter of the carbon is increased. For instance: Taking the fifty ampere line, Fig. 109, the ⅞ carbon gives a trifle less than 7,000 candle power, the ¾ carbon a trifle less than 8,200 candle power and the ⅝ gives 9,400 candle power. Or, taking the 8,000 candle power line we find that the ⅝ carbon gives that candle power at a bit less than 55 amperes, the ¾ at a bit less than 50 amperes and the ⅞ at a bit less than 55 amperes. We also see that this difference holds good clear up to the capacity of the ⅝ and ¾ carbons, which does not seem quite right. The difference should, it seems to us, decrease as the current approaches more nearly a carbon capacity.

We learn from this that if we use a ¾ carbon for amperage within the capacity of a ⅝ carbon we will be wasting almost exactly five amperes of current, and if we use a ⅞ where a ¾ is large enough we waste the same amount, whereas when we use a ⅞ where a ⅝ is large enough we waste ten amperes, which, if we take current through rheo-

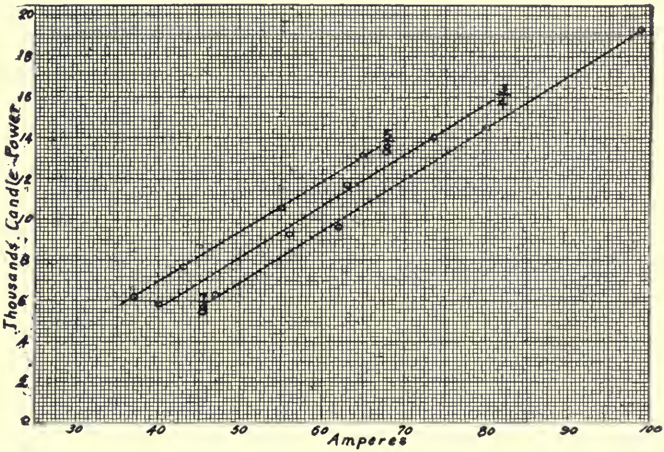


Figure 109.

stats from a 110 volt line, will mean 1,100 watts of energy wasted.

Mr. Binkelman attributes the difference to the fact that the larger carbon has a larger radiating area and a greater cross-sectional area, hence more heat is radiated away from the crater, with result that its temperature is reduced, in which view we hold him to be entirely correct. It is but another way of saying that the comparatively large amount and comparatively cool carbon near the crater floor reduces the temperature of the floor.

Fig. 110 is the same as Fig. 109, except that a different make of carbon was used. It will be noted that the difference in candle power per ampere is greater with this kind of carbon, also there is a slight variation when we compare the difference between the ⅝ and ¾ and the ¾ and ⅞. Why this is we are unable to say positively, but it surely must be due to peculiarity of either the ⅝ or the ⅞ carbons used for the test. The fact remains, however, that different makes of carbon evidently do make for somewhat different results when over-size carbons are used.

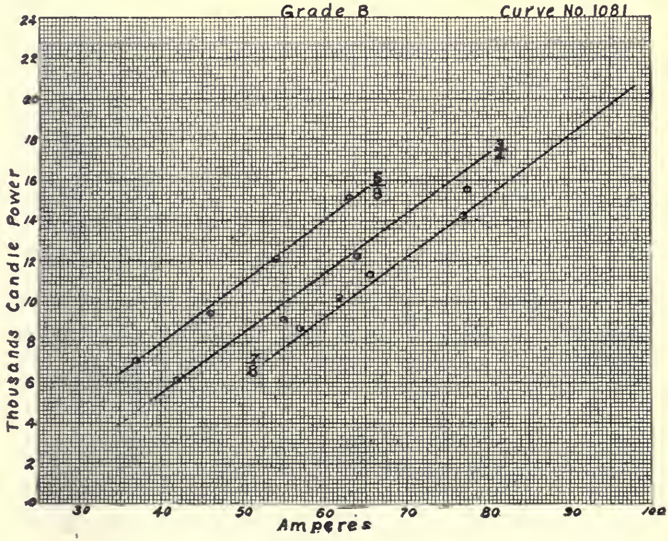


Figure 110.

In Fig. 111 the curves (in charts of this kind the lines are called "curves," even though they be straight lines) show that crater area increases exactly in proportion to increase in amperage when we consider a carbon of given size, but that the crater area for a given amperage increases as carbon size is increased. It is curious that according to this chart this holds exactly true regardless of how much the carbon may be under-loaded. For instance, we see, Chart A, Fig. 111, that at forty-five amperes the craters of ⅝, ¾ and ⅞ carbons are respectively (roughly) .13, .16 and .18 of a square inch. Referring back to Fig. 110 we find that the ⅝ carbon has a greater total light giving power for a given amperage than the ¾ or ⅞ carbon. We thus arrive at the inevitable conclusion that:

Crater area per ampere is greater with the larger carbon, but the light giving power per unit of crater area decreases as carbon size is increased.

Concerning this Mr. Binkelman says: "Let it be understood, however, that the amount of light, or intrinsic brilliancy per unit crater area should be very nearly equal for

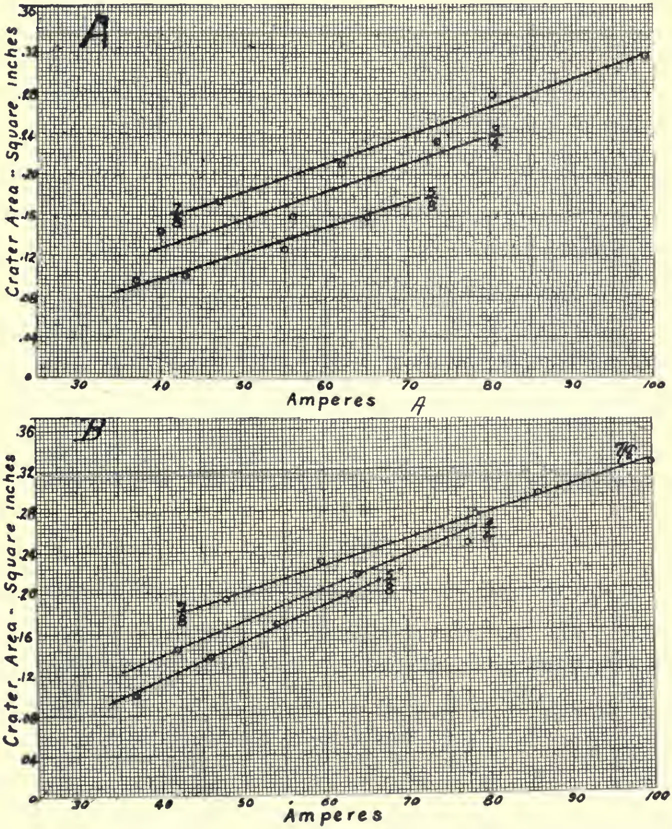


Figure 111.

the different size carbons when the craters are well saturated."

By "saturated" it is meant when the carbon is working close to its normal capacity. In this view we concur, though it seems to be to some extent contradicted by the charts in Fig. 111, especially in Chart A.

Fig. 112 is an efficiency chart. In some respects it is not quite as understandable as we would like it to be, but one fact stands out clearly, viz.: taking sixty-five amperes, for example, we find that whereas with a five-eighths carbon it requires about .29 watts to produce one candle power, with a three-quarters carbon something more than .32 watts are required and with a seven-eighths carbon just .36 watts are necessary. The waste in under-loaded carbons is thus again made apparent, since a waste of .03 watt per candle power would mean 480 watts waste in a 16,000 candle power arc.

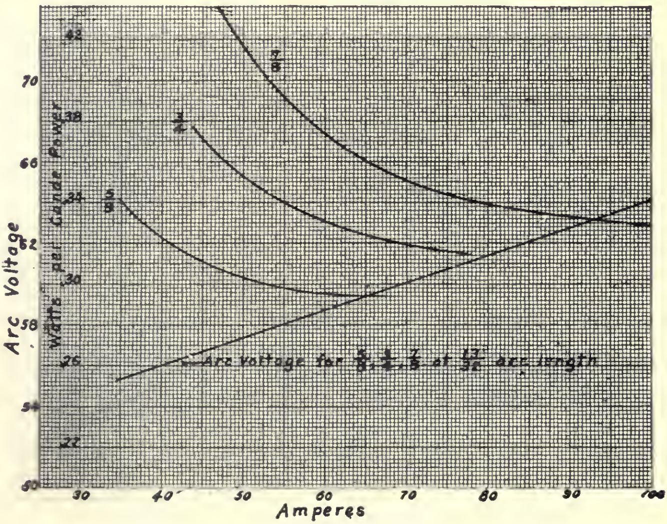


Figure 112.

From the experiments Mr. Binkelman concludes that the most efficient point at which to burn carbons is just below the point where the crater is completely saturated, beyond which point penciling is set up.

In Fig. 113 we see the effect of "penciling" or "needling" of carbons, which occurs when the carbon is working above its maximum capacity.

Note: Penciling may begin at a point far below the normal capacity of a carbon, when conditions, such as poor contact or abnormal temperature inside the lamphouse, act to reduce its capacity by adding to the temperature caused by ordinary current action.

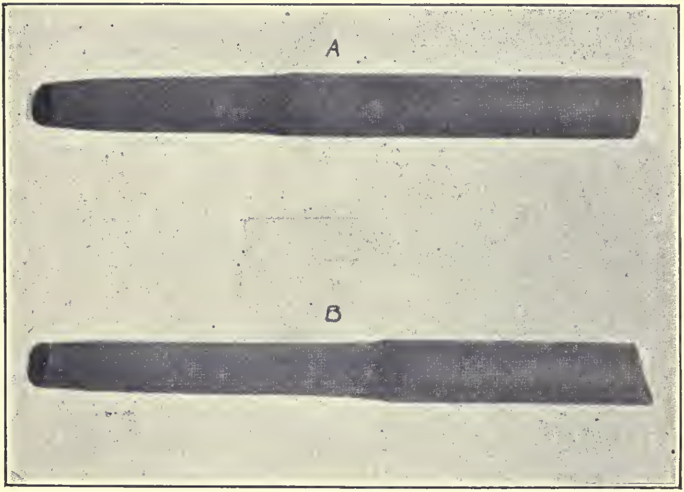


Figure 113.

In Fig. 114 we get a glimpse of the effect of amperage on crater shape and area, remembering that in the picture the actual size is greatly reduced. Actual crater size may be determined by increasing the dimensions of the crater as many times as it is necessary to increase the diameter of the carbon in the picture to make it the actual measurement of the carbon itself. The craters are for two grades, or makes of carbon, designated as "Grade A" and "Grade B."

The rule is therefore established that the practical operating point of greatest efficiency is a point five amperes below the penciling point of any given carbon.


Grade A Carbons
5/8 Dia.
Amperes 35 47 55 68
3/4 Dia.
Amperes 40 56 73 85
7/8 Dia.
Amperes 47 62 80 102
Grade B Carbons
5/8 Dia.
Amperes 37 46 54 65
3/4 Dia.
Amperes 42 53 64 77
7/8 Dia.
Amperes 57 66 77 100

Figure 114.

Either above or below the penciling point efficiency falls off, and five amperes below penciling is as close as it is practical for the projectionist to approach the actual capacity of the carbon. This means, however, that the projectionist must himself determine the penciling point of any given lot of carbons, since not only will the penciling point vary with different makes of carbon, but also to some extent with different lots of the same brand.

Determining the penciling point is a simple matter, since the projectionist has but to install a set of the new carbons and gradually increase amperage until penciling starts, whereupon five amperes less current will be the correct operating point for that particular lot of carbons, as nearly as it is practical to determine it.

Mr. Binkelman says: "To give Grades A and B a rating in amperes would result about as follows: 55 to 60 amperes use 5/8 carbons; 75 to 80 use 3/4 carbons, and between 90 and 95 amperes use 7/8 carbons."

It will, however, be noted that this leaves gaps of considerable amount, and in any event it could be only approximately correct. On the other hand, Mr. Binkelman has made about the only suggestion available in practice, because of the limitation in carbon sizes.

We need carbons the diameter of which progress by sixteenths of an inch instead of eighths, but they will not be available until projectionists evince sufficient interest in efficient work to demand them.

The whole matter may be summarized roughly as follows: (a) candle power is directly proportional to current, up to maximum capacity of a carbon; (b) decreases with increasing carbon diameter, at a given current; (c) maximum efficiency is had only when a carbon works just below its maximum capacity—its penciling point; (d) crater area is directly proportional to current for a given size carbon, and increases with carbon size at the same current (see further comment, Page 381); (e) arc voltage increases directly in proportion to current increases; (f) quantity of carbon (cubic inches) consumed varies directly with current, and is independent of carbon size at any given current.

The foregoing constitutes a valuable discussion of the various points treated, both from the theoretical and the practical viewpoint. As applied to practice it all sums up in the proposition that the projectionist, having first selected the brand of carbon he proposes to use, should make tests of various sizes and determine which size will come nearest to burning at five amperes under the penciling point at the amperage he desires to use.

If carbon companies put out tables suggesting the amperage their carbons are to be used at it should be distinctly stated thereon that the amperage given for the various sizes is the nearest practical approach to five amperes below the penciling point.

INSPECTION.—The projectionist should carefully examine each bundle of carbons before using. Cracks running lengthwise of the carbons are in a way characteristic of the product, and do no harm. They are caused by slight error in the consistency of the paste from which they are formed. Chip cracks running around the circumference, however, condemn the carbons, since there would be a tendency to break off at this point, though hair cracks are often found running around the circumference of good carbons. They are due to the same cause as the longitudinal cracks, and are of no consequence.

EXAMINE CORES.—The ends of cored carbons should be carefully examined, and if too many of them show indication of imperfection in the core they should be rejected. It is absolutely essential to high class work on the screen that all cores be thoroughly continuous, also that the core adhere to the wall of the carbon sufficiently well to prevent short sections of it dropping out as the carbon is consumea. Carbon with a section of its core lacking is one of the most annoying things the projectionist is called upon to deal with. Absence of the core not only produces unsteadiness in the light while that section of the carbon is being burned away, but also alters the tone of the light, and if the center of the crater is in focus at or near the film plane, the absence of the core will produce a dark spot at the center of the screen.

HARD SPOTS in the carbon due to faults in manufacture were of very common occurrence in the early days of projection, and were a source of great annoyance to the projectionist. Such spots are believed to be caused by the lack of thorough mixing of the carbon dough in the early stage of manufacture. They are, however, now so seldom encountered that they may be said to have been to all intents and purposes eliminated.

HARD AND SOFT CARBONS.—Some carbons which are too hard have a tendency to produec yellow light through faulty cratering and slow burning, with resultant short arc and increased tendency to interference by the lower carbon tip. All these things result in an unsteady light of relatively low intensity. On the other hand, carbons which are too soft burn away rapidly, hence are not economical, though they usually provide good illumination while they last.

CARE OF CARBONS.—It is essential to good results on the screen that the projection carbons be thoroughly dry. Carbons should, therefore, not only be stored in a dry place, but thorough dryness should be further insured by mild heating for a day or two before using. This latter may be accomplished by attaching a pair of hooks to the lamp house as indicated in Fig. 115, but it is recommended that projector manufacturers provide some sort of carbon receptacle either in or on the top of the lamp house, capable of containing from six to a dozen carbons, both negative and positive.

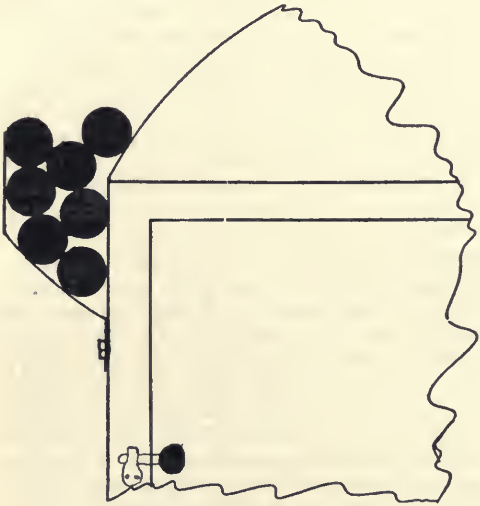


Figure 115.

BURNING CARBON STUBS.—Modern projection lamps accommodate 6 inch lower and 12 inch upper carbons, but it it is not always practical, particularly where 2,000 foot reels are used, to burn carbon stubs very short in the regular way.

There are now on the market any number of "carbon economizers" which are nothing more nor less than a metal shank at the top of which is a receptacle in which the carbon stub is clamped by means of a suitable mechanism. This arrangement clamps in the regular lamp carbon jaw and allows of the carbon stubs being burned down until only an inch or two remains. They may be had of any supply dealer.

EQUIVALENTS.—The equivalent of millimeters in fractions of an inch will be found on Page 906.

ALTERNATING CURRENT CARBONS.—There are now several brands of cored projection carbons on the market designed particularly for use with alternating current. These carbons have a special chemicalization, and by reason of the gases produced not only give much steadier light than do ordinary carbons, but, also due to the chemicals, the light is of a whiter, more brilliant tone. Two of these brands have been thoroughly tried out and found excellent, viz.: The "Columbia White Flame A. C. Projector Carbons," made by the National Carbon Company, and the "Alterno," made by the Speer Carbon Company. These carbons are very much better than ordinary D. C. carbons for A. C. They should be used wherever an alternating current projection arc is operated.

The Columbia white flame A. C. projector carbons were the first flickerless, noiseless and satisfactory alternating current combination ever used. These carbons reduced the noise of the A. C. projection arc to less than the usual shutter noise. The screen light was changed from a decidedly yellow color to a snow white, with a remarkable increase in better seeing power, cleaner looking pictures, better perspective, better film penetration, especially with tinted films, and brighter pictures. The candle power per arc watt (or per dollar spent for power) was improved from 10 to 30 per cent. The latest results with these special A. C. carbons show a marked increase in screen candle power at high currents. This has opened a new era of development for A. C. arc projection with currents up to 100 amperes.

WHAT DO YOU MEAN IT CAN'T BE DONE?

The Light Source

WHERE the electric arc is the source of projection light, practically all illumination available for use comes from what is known as the "crater," which is a more or less saucer-shaped depression formed on the tip of the positive carbon by the action of the current. When direct current (D. C.) is used at the arc there is only one crater formed, because a crater forms on the positive carbon only, and with D. C. one carbon is always positive and the other always negative. When alternating current (A. C.) is used at the arc, however, a different condition is set up, because a crater always forms on the tip of the positive carbon, and with A. C. at the arc each carbon is alternately positive and negative. It therefore follows that where A. C. is used at the arc a crater forms on the top of both the upper and lower carbon, and since the crater forming force of the current is thus divided, it also follows that the craters formed are very much smaller than those formed by an equal amperage of D. C. This is true to the extent that the combined area of the craters on both carbons of an A. C. arc will not equal the area of the single crater formed on the positive carbon tip of a D. C., arc amperage being equal in both cases.

USING A. C. ARC FOR PROJECTION.—Experience has amply demonstrated the fact that when using an A. C. arc for projection, best results are had when the light from one crater—the upper—is used. Any attempt to utilize the light from both craters will inevitably result in inferior results at the screen. True there are those who claim to have successfully used the light from both craters for projection, but we have yet to examine a single instance where the claim was made good when all the facts were examined.

When we therefore consider that the light from only one crater is available; that the crater is very much smaller than the D. C. crater of equal amperage, and that the crater brilliancy per unit of area cannot be higher than that of the D. C. arc, it becomes manifest that the light available to the collector lens from an A. C. arc is very much less in amount than is the light from a D. C. arc of equal amperage, assuming the two arcs to be adjusted at the point of highest efficiency with relation to the collector lens.

In this connection, however, let it be noted that for some reason never explained to our entire satisfaction, the light from an A. C. projection arc has a higher power of penetration and a whiter brilliancy than has light from the D. C. arc.

While this may be accounted for in part by difference in chemicalization of A. C. and D. C. carbons, chemicalization cannot account for it all, as the same thing was to some extent true some years ago when the same carbons were used for both A. C. and D. C. We are inclined to believe it is in some measure due to the fact that the A. C. arc produces less gas than does the D. C. arc of equal amperage, and that the heavy D. C. arc stream operates to soften the tone of the light either by adding a yellow tinge or by screening out those rays which give the light the qualities named. This is, however, by no means made as a statement of fact. It is set forth merely as forming an interesting field for study by the projectionist, by carbon manufacturers and others interested. As a matter of fact the violet lines in the spectrum of the arc stream are said to be brighter than from the crater itself, this latter being tentatively explained in two ways: (a) that the arc stream is higher in temperature even than the crater floor; (b) that the flow of current through the gas causes it, the gas, to have luminosity without regard to its temperature, meaning that the current flow causes electro-luminescence, as in a vacuum tube or the aurora borealis. (See Professor Gage's book on Optic Projection, Page 546.)

CAUSE OF LIGHT.—The brilliancy or light producing power of the floor of the crater of an electric arc is due entirely to its high temperature. The reason the crater forms on the positive carbon is because it gets hotter than does the negative, and the reason it gets hotter is because it offers higher resistance.

The various elements of the arc offer resistance in the proportions indicated by the following. Taking for example a 60 volt D. C. arc, we find the voltage drop caused by the various elements to be as follows:

Positive crater causes a 35 volt drop.
Negative carbon tip causes a 10 volt drop.
Arc stream causes a 15 volt drop.

This indicates to us that the positive crater offers 58 per cent. of the total resistance of the arc, the negative crater only 17 per cent. and the gas stream 25 per cent. With this in view we readily see why the positve carbon tip gets very much the hotter of the two, why it burns away faster and thus forms a "crater," and why it is very much the more brilliant of the two.

CRATER TEMPERATURE.—The light giving power of the floor of the crater of an electric arc depends upon two factors, viz.: (a) its temperature per unit area, and (b) its total area. Its total light giving power will, therefore, be its candle power per unit area (usually taken in square millimeters) multiplied by its total number of units of area.

So far as we know the actual temperature of an electric arc crater has never been accurately measured, but it has been estimated at 3.427 degrees Cent., or 6,200 degrees Fahr. (See Bulletin Bureau of Standards, Vol. 1, Page 909.). Later investigations, however, indicate that the temperature of the positive crater is decidedly higher than this. (See book by Lummer.) By comparison the temperature of the sun is given as about 6,500 degrees Cent., the acetylene flame 2,057 Cent. and the ordinary gas flame 1,557 Cent.

Whatever the exact measure of its heat in degrees, however, it is that temperature necessary to volatilize carbon, the most refractory substance known to science, and it is this latter fact which makes it the most brilliant artificial light mankind has been able to produce. Much interesting and valuable information on the electric arc will be found in Optic Projection, Pages 536 to 571.

CANDLE POWER OF CRATER.—Experiment has shown that under any given set of conditions the candle power of the crater of an electric arc, using cored carbons, remains stationary at somewhere between 130 and 160 c. p. per sq. mm. when the carbon is working at or near its capacity, but that this brilliancy per unit of area may be considerably lowered by working a carbon appreciably below maximum capacity.

In other words, the brilliancy per unit of area is stationary, regardless of the number of amperes, provided the size of carbons in all cases be such that it will work at or near capacity. (See important foot note on page 412.)

We may therefore say that, regardless of amperage, with a carbon working at or near capacity, its crater brilliancy will be about 150 C. P. per square mm., which figures out 48,-300 C. P. for a crater having an area of .5 of a square inch. Bearing this in mind it will be seen that increase in amperage will produce increase in total luminosity at the rate of about 150 C. P. for each square mm. increase in crater area.

Experiments have determined that with a 55-degree crater angle, the crater area increase per ampere is a somewhat variable quantity with different makes of carbon.

Note: At our request the National Carbon Company undertook experiments to determine, accurately, the effect of current increase on crater area. We are indebted to Mr. W. R. Mott, of the National Carbon Company laboratories, for the following remarkably complete and in every way excellent data:

Data on Crater Area of Positive Cored Columbia Uppers with Columbia "Silvertip" Negative Lowers:

TABLE NO. 18

Size of Carbon inch	Amperage	Crater Area inch	Crater Width inch	Crater Length inch
½	25	.05	.24	.28
⅝	35	.08	.32	.37
⅝	50	.15	.41	.48
⅝	60	.16	.42	.48
⅞	80	.33	.57	.71
⅞	100	.37	.60	.74

1 mm. is .00155 of a square inch, or 645.2 sq. mm. in 15 square inches.

The area in the above cases was measured by means of a planimeter on the burnt form of the crater, which was obtained by impressing the white hot carbon on a block of hard wood. A further check on the area is obtained by using the formula for the area of an ellipse whose diameters are represented by the width and length of the crater as given in the above table.

The direct observation of the length of the crater was also obtained by projecting an image of the arc with a magnification of 2.5. The average results of a number of tests of the length of the crater were as follows:

TABLE NO. 19

Size of Positive Carbon	Amperage	Crater Length
⅝ in.	25	.28 in.
⅝ in.	35	.34 in.
⅝ in.	50	.46 in.
⅝ in.	60	.48 in.
⅞ in.	80	.67 in.
⅞ in.	100	.70 in.

The results of the two methods give reasonable checks.

As a result of much study of crater areas, we find it increases more rapidly than proportional to the current.

If the current be doubled, the crater area increases 2.46 times. The candle power of the carbon arc also increases

2.46 times when the current is doubled. In the form of the simplest mathematical terms this means that the crater area and candle power increase as the current to the 1.3 power. The following formula expresses this relationship:

Crater area $= KC^{1.3}$ for crater area in square inches, in which $C =$ current in amperes and $K = .00092$. K is calculated for Columbia carbons only.

The error has been made by Messrs. Aryton, G. F. Binkelman and others that crater area is proportional to the current. This is not true where the proper size of carbon for correct service is used for ordinary projection, or for searchlights. In the following table we have arranged together the observed and calculated results on the basis that crater area increases 2.46 times when the current is doubled. It will be noticed that the observed results and calculated results agree satisfactorily.

TABLE NO. 20

Amperage	Observed Crater Area	Calculated Crater Area
25	.05 sq. in.	.06 sq. in.
50	.15 sq. in.	.15 sq. in.
100	.37 sq. in.	.37 sq. in.

HIGH AMPERAGE WASTEFUL.—It is thus seen that by increasing carbon size and amperage we may cause the generation of almost any number of candle power at the crater, but as will be shown, the projector lens system as now constituted, is unable to utilize the whole of the illumination produced by a D. C. arc if current flow be in excess of about 60 amperes. Beyond that point there is unavoidable loss, in increasing amount, as the current flow is increased until at about 120 amperes a point is reached where further increase in current flow brings no result in increased light at the screen. It is possible, though we believe hardly probable, that improvements in the optical system may overcome this difficulty.

The Speer Carbon Company has, at the request of the author, compiled the very complete data contained in table No. 21 as to crater area and arc voltage, at varying current strengths, for Speer Directo positives and Speer Hold-Ark negatives.

The results appear in complete form in table No. 21, the results as to crater area found therein being summarized in Fig. 116.

We feel that the thanks of the profession are due to the National Carbon Company and the Speer Carbon Company for having made such complete data available.

TABLE NO. 21

Crater Areas of Projector Carbons at Different Amperages Direct Current

Speer Directo Positives				Speer Hold-Ark Negatives		
Pos. Inch	Neg. Inch	Amps.	Volts	Size of Crater Inch	Crater Area Inch	Angle Degrees
7/8	7/16	85	56	.603 x.784	.3694	56
		86	57	.600 x.788	.3713	55.5
		85	55	.537 x.739	.3120	56
		85	58	.538 x.750	.3175	56.5
		85	57	.588 x.799	.3689	59
		85	57	.558 x.766	.3357	56.5
		86	57	.577 x.788	.3562	56.5
	Average	85.4	56.7	.5715x.7734	.3472	56.5

Speer Directo Positives				Speer Hold-Ark Negatives		
Pos. Inch	Neg. Inch	Amps.	Volts	Size of Crater Inch	Crater Area Inch	Angle Degrees
3/4 +	3/8	66	52	.455 x.628	.2246	56.5
		65	53	.440 x.631	.2183	55.5
		65	52	.464 x.629	.2293	59
		66	53	.467 x.657	.2411	59
		64	51	.447 x.619	.2175	54.5
		66	52.3	.483 x.640	.2427	58
	Average	65.3	52.5	.462 x.6323	.2273	57.5

Speer Directo Positives				Speer Hold-Ark Negatives		
Pos. Inch	Neg. Inch	Amps.	Volts	Size of Crater Inch	Crater Area Inch	Angle Degrees
5/8 +	11/32	45	53	.367 x.483	.1392	53.5
		46	52	.376 x.474	.1321	54
		46	54	.375 x.470	.1385	54
		45	52	.380 x.495	.1477	56
		46	53	.368 x.478	.1381	56
		45	52	.378 x.500	.1483	56
		46	54	.370 x.470	.1365	53
		46	54	.385 x.495	.1467	56.5
		45	53	.380 x.485	.1447	56.5
	Average	45.5	53	.3754x.4832	.14131	55.0

Speer Directo Positives				Speer Hold-Ark Negatives		
Pos. Inch	Neg. Inch	Amps.	Volts	Size of Crater Inch	Crater Area Inch	Angle Degrees
1/2	5/16	27	45	.287 x.354	.0797	54
		26	45	.291 x.341	.0779	54
		26	45	.273 x.353	.0757	53
		26	46	.275 x.359	.0783	55
		25	45	.278 x.355	.0775	54.5
		26	47	.265 x.352	.0732	53.5
	Average	26	45.5	.277 x.3523	.07705	54

WHAT HAPPENS WHEN AMPERAGE IS INCREASED.—The projectionist who has means available for increasing current flow gradually from about 25 to 100 amperes may conduct an experiment which should not only be interesting but highly instructive. He may even learn considerable if he can only increase amperage from about 25 to 60 or 80. Proceed as follows:

With 25 amperes D. C. flowing, and the crater carefully adjusted to give a good spot, place over the surface of the converging lens a metal plate in the center of which is a very small hole—the very smallest you are able to make. If necessary, have a jeweler drill the holes for you, using one of his smallest drills. Use very thin metal, such as thin tin, and do not place the metal in the slide carrier, but right up just as flat against the face of the lens as you can get it. Unless the plate actually rests against the glass at the point where the hole is, the experiment will not be satisfactory.

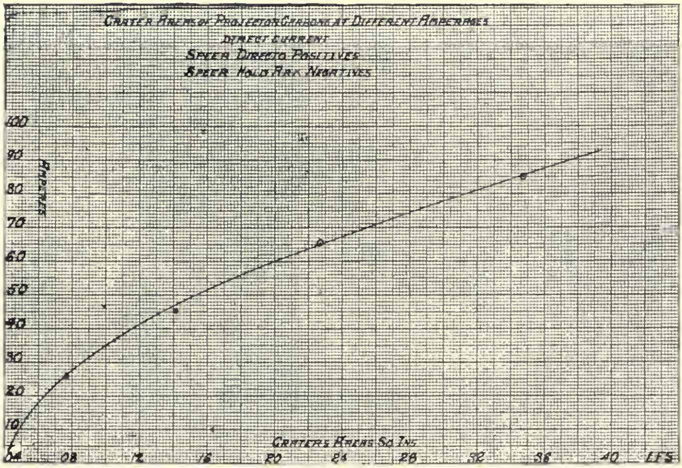


Figure 116.

This will produce on the fire shutter of the projector a bright spot of light which may or may not be surrounded by a halo of considerable size. The small bright center is a pin-hole photograph of the crater of the arc. The result as to size of spot will depend upon relative distance of crater and aperture from optical center of the condenser, the enlargement of the crater image over the crater being as many times as the first distance is contained into the second.

Having examined the spot of light thus produced, increase the current flow by 10 or 20 ampere steps, stopping on each change long enough for the crater to increase its area to conform to the increased amperage. You will find the image of the crater will increase in size with each increase in amperage, until finally it will cover the entire aperture. This latter point will be reached at somewhat varying amperage, depending upon the magnification of the light source at the spot. Ordinarily, however, we believe we are safe in saying that at between 50 and 60 amperes D. C. the image of the crater projected through the pin-hole in the center of the condenser will cover the entire aperture.

When you have reached this point, pause and consider the matter. What does this mean? We shall presently see: When the point is reached where the crater image projected through the center hole covers the entire aperture, substitute another plate in which is a similar hole drilled one-half an inch from the center of the metal plate—optical axis of the condenser. You will find that the image projected through this hole will not fall quite central with the aperture of the projector, but a little to one side. Also the crater image will not cover the entire aperture, though nearly so, amperage being equal to that required for the image projected through the center hole to just cover the aperture. By increasing the current flow a little beyond the amperage necessary for the image projected by the center hole to cover the aperture, you will find that the image projected by the hole a half inch off center will also cover the aperture. In other words, the latter crater image must be a trifle larger than the first one in order to cover the aperture, because its center is out of center with the aperture.

Stop and think again. What does this mean?

Next drill a third hole, of equal size with the others but one inch from the center of the plate. The image of the light source projected through this hole will have to be still larger than either of the others in order to cover the entire aperture, because its center is still further out of center with the aperture than was the last one. By increasing the amperage sufficiently, however, a point is reached where it is large enough to cover the entire aperture, but when that happens it is decidedly larger than the first central crater image and considerably larger than the second image.

Again stop and think. What is the condition now? Why, just this:

The condenser for a distance one inch in every direction from its optical axis is working at full capacity, insofar as has to do with an aperture of that size. In no possible way could any more light be gotten through an aperture of equal

dimensions under that condition as to magnification of light source at the aperture. The center zone of the condenser represented by a two-inch diameter circle is working at its absolute maximum capacity, insofar as has to do with an aperture of that size under that condition.

By further increase in current flow the center zone can be made to pass an increased amount of light, yes, but it would all be wasted on the cooling plate, not a single ray getting through the aperture.

If we now continue our experiment by drilling other similar size holes by half inch steps, clear out to the edge of the free diameter of the converging lens of the condenser, we shall find that increasing amperage produces less and less increase in light as more and more of the area of the condenser comes up to its maximum working capacity, until finally, usually **at about 120 amperes, it will be found impossible to get more light through the aperture because the entire condenser is working to capacity.**

This explains why it is that when we increase the amperage up to say 55 amperes, the increase in light is about in proportion to the increased amperage, because up to that point none of the condenser is working up to capacity, but beyond that point it begins to slow up, and as more and more of the condenser comes up to maximum working capacity, the slowing up is more rapid, until a point is reached at about 120 amperes where very little if any further perceptible screen brilliancy can be had.

VALUABLE DATA.—The foregoing conclusion is supported in its entirety by experiments conducted by Mr. W. R. Mott, of the National Carbon Company's laboratories, which were described in an article, "As to Increased Amperage and Screen Illumination," Page 1186, May 24, 1919, issue of Moving Picture World, in which the experiments were described as follows:

"The screen candle power was determined as the average of many readings with a Scharpe Miller Photometer Lamp standardized by the Bureau of Standards at Washington. The screen was a 7 by 9 foot with a 67 foot throw. The entire purpose was to obtain the percentage gain in candle power with increase in amperage, using proper size trims corresponding to the amperage. Columbia cored uppers were used with Columbia Silver Tip negative lowers.

"Increase in current from 30 amperes to 50 amperes gave 160 per cent. gain in screen candle power.

"Increase in current from 50 amperes to 70 amperes gave 46 per cent. gain in screen candle power.

"Increase in current from 70 to 90 amperes gave 18 per cent. gain in screen candle power.

"Increase in current from 90 to 110 amperes gave 15 per cent. gain in screen candle power.

"Increase in current from 110 to 130 amperes gave 12.5 per cent. gain in screen candle power.

"The above data were obtained with the usual lens system consisting of 6½ and 7½ inch focal length condensers, with a fourth size projection lens.

"Beyond 120 amperes D. C. the increased amperage gives no appreciable increase in screen brilliancy, nor is it possible with a projector aperture of the present size, to change this condition.

ARC VOLTAGE.—A projection arc at a given amperage operates most efficiently with the carbon tips a certain given distance apart. Any alteration in this distance will operate to decrease the brilliancy of the light. This distance varies with the amperage, and what we call the "voltage of the arc" is the E. M. F. necessary to force the current from one carbon tip to the other against the comparatively high resistance of the arc stream. Put in another way, arc voltage is the electrical pressure or voltage necessary to force the current across the space between the carbon tips. The arc voltage is the reading of a voltmeter when it is attached to the upper and lower carbon arms, or carbons, with the arc in operation. Just what the actual best voltage value may be for different amperages we do not at this time know, nor do we believe that the matter could be set down in figures. because in our opinion much would depend upon the carbons themselves. The National Carbon Company, however, recommends Table 22 where their carbons are used, and data of value also appear in Table No. 21.

It seems reasonable to suppose that, regardless of amperage, arc voltage would alter with volume and character of the arc stream, and there can be no doubt but that diffrent makes of carbon do give off gases which are not only of different volume but of different character.

In this connection, we might add that there seems the possibility for development in projection carbon manufacture along this line. It may be possible that carbons could be developed which would, without any sacrifice in other directions, provide a gas stream which would permit of, or even demand, a comparatively wide separation of the carbon tips for best results, and this would act to automatically and entirely eliminate lower carbon tip interference, which now under many conditions operates to cut down the total illumination delivered to the collector lens.

ARC VOLTAGE WITH RELATION TO AMPERAGE FOR PROJECTION CARBONS

Table No. 22

Columbia Positives with "Silver Tip" Negatives on direct current.

Arc Amperage	Proper Arc Voltage
30	52
40	54
50	56
60	58
70	60
80	62
90	64
100	66

For alternating current with Columbia White Flame Combination.

Arc Amperage	Arc Voltage
50 or 60 amps.	28
70	30
80	32
90	34

INTERESTING DATA.—Simon Henry and Henry Phelps Gage, of Cornell University, have conducted experiments with D. C. regular carbon sets which resulted as follows: A 15 ampere 50 volt arc taking current through a rheostat, consuming 750 watts in the lamp and 1,650 watts in total, gave a total of 3,490 C. P., or 4.65 C. P. per watt of energy, consumed in the arc, or 2.12 C. P. per total watt consumed in the arc and rheostat. A 40 ampere 51 volt arc, taking current through a rheostat, consumed 2,040 watts in the arc, or 4,400 watts total, and gave 12,350 C. P., which is 6.05 C. P. per watt consumed in the arc or 2.8 C. P. per watt consumed in both the arc and the resistance.

An examination of these figures is interesting. It apparently shows a less C. P. per total watt of energy consumed in a 40 ampere arc than in the arc of lower amperage, because while it is true there is a gain of 1.4 C. P. per watt of energy expended in the 40 ampere arc, as against the 15 ampere arc, there is an actual loss of .04 C. P. per watt when we come to examine the figures as applied to the total amount of energy expended.

We are inclined to believe, however, that this slight loss is chargeable to the fact that the voltage of the arc remained practically constant where in a projection arc there would be considerable variation as between a 15 and a 40 ampere arc. We do not quote these figures as having any considerable value, except insofar as they point out to the projectionist the possibilities for interesting experiments and study along these lines.

In the course of these experiments it was shown that a mercury arc rectifier arc, using 40 amperes at 52 volts, regular D. C. carbon set, gave 12,150 C. P., a 40 ampere 27 volt A. C. arc gave 1,830 C. P., a 40 ampere 51 volt D. C. arc gave 12,350 C. P., carbon set being the same in all cases, (see tables Pages 556-57 Optic Projection) which indicates that direct current through a rheostat and alternating current taken through a mercury arc rectifier have approximately equal illuminating power, but when A. C. is used at the arc the illuminating power is very much less indeed.

Through the courtesy of the Comstock Publishing Company we are enabled to present two charts illustrating the relation

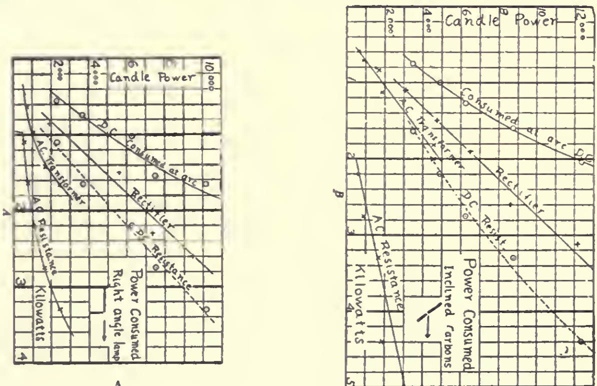


Figure 117.

between the power consumption and candle power, in which it is shown that with the right angle lamp (Chart A) A. C. through a rheostat (resistance) gives the least amount of light per K. W., A. C. with a transformer gives more light than when a rheostat is used, and A. C. through a rectifier gives the greatest amount of light. D. C. with a rheostat gives less light per watt of energy consumed than does A. C.

through a rectifier, while D. C., if only the power consumed at the arc be considered, gives the greatest illumination of all for a given power input, (left upper curve) i.e., 10,000 C. P. for less than 2 K. W. of power consumed.

Chart B, in which the regular D. C. set is used, shows that A. C. with a rheostat (resistance) gives the least amount of light per K. W., D. C. with a rheostat next, A. C. with a transformer next, and A. C. with a rectifier the greatest illumination of all per watt of energy consumed, though the upper left-hand curve shows that straight D. C. gives the greatest amount of light of all if only the power consumed by the arc be considered, and the waste in rheostat be not taken into account.

If the two diagrams be closely compared, it will be found that the right angle lamp gives the most light for the same current in every case, though the light given for the same power input is the same with both styles of lamps. With either A. C. or D. C. and resistance the right angle lamp gives the greater amount of light, but with A. C. and a transformer the right angle lamp gives the least light. This is due to the higher voltage of the right angle arc when used with A. C., the right angle arc requiring about 50 volts whereas the inclined carbon required but 30.

In actual practice the foregoing conclusions must be modified by the fact that D. C. through a rheostat is cheap in first cost of installation, also requires slight expense in upkeep of the apparatus thereafter, whereas the mercury arc rectifier is a rather costly piece of apparatus and there is the item of replacement of tubes, as well as other possible repairs to the machine to be taken into consideration, which we believe will fully balance if not more than balance the apparent gain of alternating current taken through a rectifier as against D. C. through a rheostat. It might also be mentioned that operation at higher amperage than is feasible with the mercury arc is frequently desirable.

SETTING THE CARBONS.—In considering light for projection, one item is of prime importance; viz: the position of the crater. This latter is a matter of literally huge importance and one to which projectionists have in the past paid altogether too little attention. Unlike the ordinary arc lamp, which directs its strongest light either downward, or both upward and downward, the primary purpose of the projection arc is to direct its strongest light flux upon the face of the collector lens, and this purpose cannot be accomplished

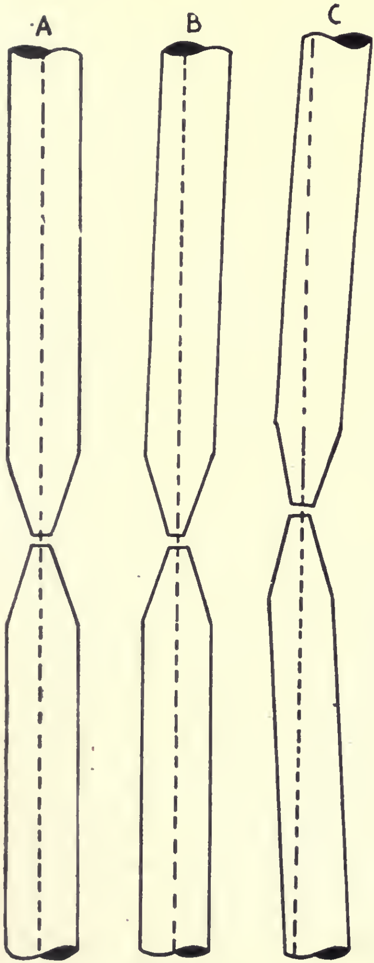


Figure 118.

unless the crater is in the best possible position, which means the position most nearly facing the collector lens.

The position of the crater is to some extent influenced by the angle of the lamp as a whole, which same to some extent will vary with the local conditions, because of the varying pitch in projection, but should be such that under ordinary conditions the carbons will have an angle of 55 degrees with the floor of the lamphouse, or 35 degrees with the face of the collector lens.

By angle of lamp we mean the angle of the lamp with relation to the axis of the optical train. Most largely, however, and in fact we might say almost entirely, the position of the crater with relation to the lens is governed by the setting of the carbons with relation to each other. In setting the carbons in the projector lamp and the adjustment of the carbon jaws of the lamp itself, it is of great importance that the carbons be absolutely in line with each other, and straight up and down as we would view them if we were to look through the condenser opening. In Fig. 118 we are presumed to be looking in through the condenser opening. A, Fig. 118, shows the upper and lower carbon not only in exact line at the tips of the carbons, but in exact line throughout their length.

TESTING THE SIDE LINE.—Upon taking charge of the projection room one of the first duties of the projectionist should be to make sure the carbons of his lamps are in perfect line sidewise throughout their entire length. This may be done by placing two new carbons of equal diameter in the lamp, and centering their tips exactly with each other. Having done this he may, by removing the condenser lenses and applying the straight edge to the sides of the two carbons and looking through the condenser opening, determine whether the carbons line exactly throughout their length.

Figure 119.

At B we see a condition where the upper carbon is out of line with the lower, and at C we see a condition where both carbons are out of line sidewise. The result of either one of these conditions would be that while the arc might burn perfectly on a new trim, the crater would gradually move toward the side of the carbon tip as the carbons were consumed, unless there be a constant sidewise adjustment of the carbons by the projectionist.

This condition may be remedied by filing the carbon clamps, or with some lamps, by loosening the bolts which hold the carbon jaw to the carbon arm, whereupon it may be possible to slightly tilt the offending jaw. If it is necessary to file the jaws the job should be done very carefully, the lamp having first been removed from the lamp house and clamped in a vise so that the filing may be done without removing the carbon jaw from the lamp.

Before making the test to determine condition B or C, Fig. 118, be sure the carbons you use for testing are themselves perfectly straight throughout their length, since a 12-inch carbon with just a little bit of crookedness at the right place would throw the carbon out considerably at its tip. If the carbon shows a condition such as at B or C, it would be well, before finally deciding there is something wrong, to test the carbons themselves for straightness, or to substitute other carbons. The manufacturers are, however, operating within very close limits as to the straightness of carbons, and very few are faulty in this respect.

Modern projection lamps have a side adjustment, so that when a new trim is placed in the lamp, the tips may be lined sidewise with each other by moving the carbon jaw.

CRATER ANGLE.—The angle of the crater to the plane of the collector lens is controlled by the amount of advancement of the lower carbon tip ahead of the upper tip. What is meant by this is made clear in Fig. 119 in which the regular D. C. set is illustrated. If the two carbons be set central with each other a condition similar to that shown in diagram A, Fig. 120, will be set up, under which the strongest light from the positive crater will follow line X, which means it is thrown directly on the tip of the lower carbon. The angle of the crater shown in sketch A is 30 degrees from the optical axis. Under this condition the zone indicated by B, which includes the upper quarter of the collector lens, would receive little or no direct light from the crater, the zone between lines B and C would receive considerable light, and the lower part of the lens would be fairly well illuminated. Such a set would of course be impossible from the projection viewpoint.

In sketch B, Fig. 120, we see a better condition, the crater being at an angle of 40 degrees to the optical axis. Under this condition the strongest light would follow broken line X. The whole surface of the collector lens would receive some direct light from the crater but the illumination of the upper half of the lens would be unevenly illuminated.

At C, Fig. 120-b, we see the ideal condition for a D. C. crater, the same being at an angle of 55 degrees with the axis of projection and an angle of 35 degrees with the face of the collector lens. Under this condition the strongest illumination would go forward along the dotted lines, but the fact nevertheless remains that as between the lower and the upper half of the collector lens there would be no large difference in illumination. This latter is partly by reason of the fact that the crater is not flat, but to a considerable degree cup-

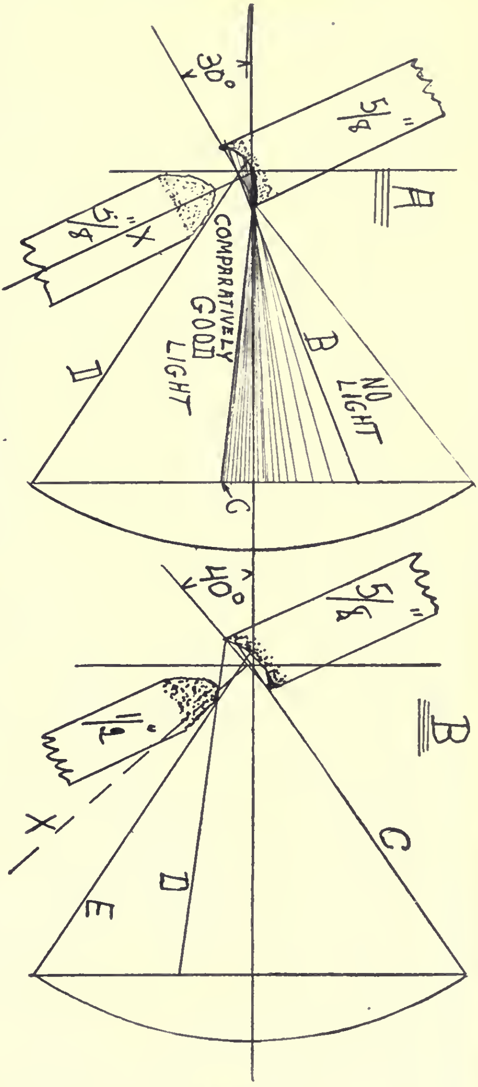


Figure 120A.

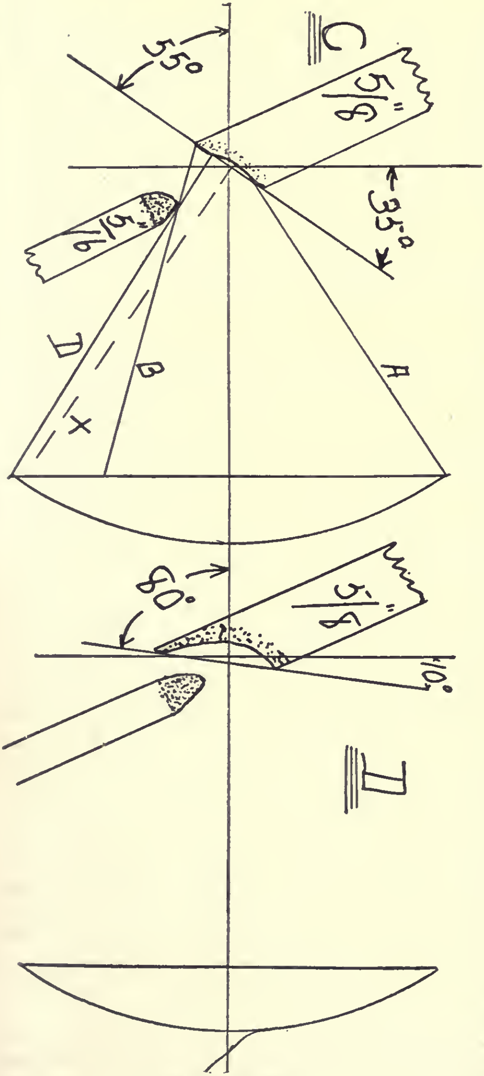


Figure 120B.

shaped, and much of the light from the lower half of its surface therefore is thrown in an upward direction.

Sketch C shows the ideal condition, except that there is a slight interference by the lower carbon tip. At sketch D, Fig. 120b, we see the result of advancing the lower carbon tip too much. The effect is that a long skirt is formed on the positive carbon, and the crater floor covers a very wide surface. Another effect is that the angle of the crater with relation to the face of the collector lens is almost ideal, the same being an angle of 80 degrees with the optical axis and 10 degrees with the face of the collector lens.

This would be a splendid condition if it were practical, but it is not because, first, under such a condition it is impossible to maintain a steady arc; second, the skirt formed on the positive carbon is very likely to break off, leaving a very imperfect crater, which of course would result in extremely poor illumination until a new one is formed; third, the floor of the crater is distributed over a very wide area, which is objectionable from two viewpoints, viz: (A), very large light source sets up serious difficulties with relation to the optical system; (B), the floor of the crater being distributed over such a wide area, its brilliancy per unit of area will not be up the maximum, due to the body of comparatively cool carbon lying so close to its face.

MAINTAINING CRATER ANGLE.—It is an easy matter to maintain the crater at the angle of greatest efficiency (55 degrees from the optical axis or at an angle of 35 degrees with the face of the collector lens) provided proper preparation has been made for so doing. To maintain the crater at its angle of greatest efficiency, however, it is necessary that an image of it be projected, either to the wall, the floor or elsewhere, and the correct angle be laid off at the point where the image falls.

The only objection to this procedure is that if the distance of the arc from the face of the collector lens be altered, as it may be, the position of the crater image will change. This objection is not, however, a serious one, because changes of the position of the arc will not occur frequently; in fact they will only occur when the focal length of the condenser is altered, or some other change is made in the optical system. Once the correct angle has been laid off on the wall, the floor or elsewhere, it becomes a very simple matter to alter its position by laying out a new line, at the same angle, in the new crater image position.

To project the crater image it is necessary to use either one of the appliances now on the market for this purpose, or to drill a very small hole in the lamphouse door exactly opposite the crater, and over this hole establish a lens. This lens may be a bit of broken condenser or even an old spectacle lens. The resultant image may be reflected to any desired point by placing a bit of mirror in front of the lens.

As a matter of fact, projector manufacturers ought to, and at least one of them has, at our suggestion, incorporated in their lamphouse door a device for projecting the crater to a small ground glass screen held out from the surface of the door perhaps 1½ inches by means of a suitable frame. It would not be an expensive thing to do, and the angle of greatest efficiency could be laid out in the form of a series of scratch marks on the glass. By making perhaps three of these marks, about ⅜ of an inch apart, the crater image would always fall near one of them even though the distance from crater to lens be altered. The thing is practical and should be done.

HOW TO FIND THE ANGLE.—In connection with the foregoing, the following directions may prove of value in enabling the projectionist to lay off a correct 55 degree angle for his crater image.

Fig. 121 illustrates the crater angle and shows plainly exactly what the 55-degree angle really means, also it illustrates the fact that when the crater is at a 55-degree angle with the optical axis, it must be and is at a 35-degree angle with the face of the collector lens. This same thing is illustrated at C, Fig. 120B.

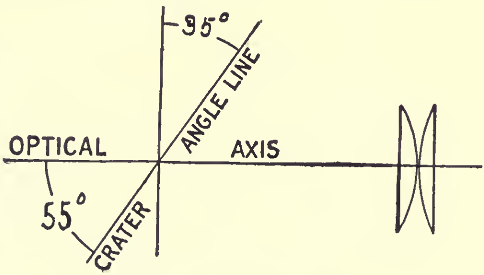


Figure 121.

In Fig. 122 we have an illustration of how the inverted image of the crater will appear when projected through a pin hole in the lamphouse door. A shows the image as it will appear if projected through a pin hole in the door on the left-hand side of the lamphouse. B is the same when projected through a pin hole in the right-hand side of the lamphouse. When dealing with the image, the line representing the optical axis should be drawn through point C, which is the tip of the crater image and represents the lower edge of the crater itself.

It is not necessary to have a protractor in order to lay out a 55-degree angle. Open an ordinary two-foot carpenter's rule, as shown in Fig. 123, until it is $5^{17}/_{32}$ inches between the two inside edges at the 8 and 18 inch mark when measured straight across from one mark to the other. The inside edges of the rule will then represent a 55-degree angle, so that if the upper edge of the lower side of the rule represents the optical axis, then the lower edge of the upper side of the rule will represent the correct crater angle.

It is not even necessary to use a rule. Just make a dot on a sheet of white paper and draw a straight horizontal line from it 6 inches long, then draw another straight line 6 inches long, one end of which will meet the other line at the dot and the other end be $5\frac{17}{32}$ inches from the outer end of the first line, measuring straight across from line end to line end. The first line represents the optical axis and the other the 55-degree angle thereto. The two lines are exactly the same thing as the inside edges of the rule.

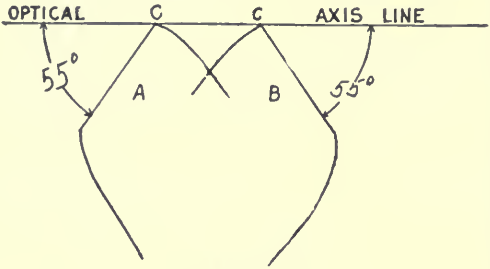


Figure 122.

Fig. 124 illustrates another method of laying out the 55-degree angle. Secure a sheet of cardboard about 6 by 8 inches in size. Trim side A-B with a straight edge. Draw lines C-D at right angles to side A-B and then lay out line F-E at a 55-degree angle to line C-D. Having done this, strike an arc and when the crater is thoroughly well burned in and the light properly adjusted at the spot, pull the projector table switch and allow the carbons to cool. Open both lamphouse doors and place the cardboard inside the lamphouse, with side A-B resting against the front wall of the lamphouse, or the condenser mount, and against the side of the carbons. Make a line on the cardboard by drawing a pencil across the face of the crater. If this line is parallel with line F-E, all is well; if not, then readjust the carbons and burn the crater until you get it right, or so that the two lines will have the same angle. When this point in the proceedings, is reached, project a crater image and mark the angle on the floor, wall or wherever the image falls.

This latter method is not a very accurate one, but it will, nevertheless, serve fairly well if the various steps be taken with care, particularly in the matter of marking the angle of the crater.

Still another method, and one which combines the advantage of a fair degree of accuracy with ease of application under all conditions, is as follows: Assuming that no means already exists for projecting the arc crater, drill a very small hole through the lamphouse door exactly opposite the edge of the floor of the crater. An inverted image of the crater will, of course, be projected through this hole. Just at the lower edge of the pin hole draw a line on the lamphouse door representing the optical axis of the lens system.

Now with a bit of looking glass reflect the image of the crater back to the hole in the lamphouse door and note its

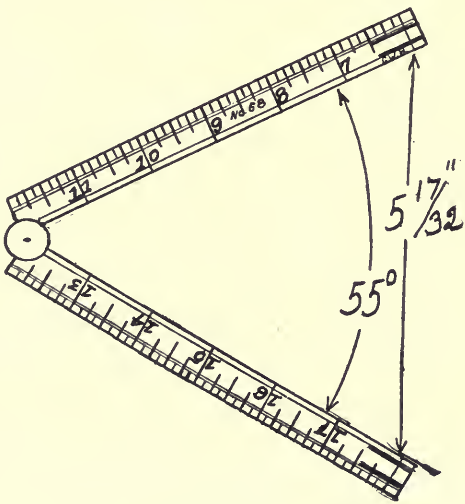


Figure 123.

position. Next draw an angle line at 55 degrees with the optical axis line and then adjust the carbons until the crater is burned so that its reflected image matches this line, whereupon pull the switch. You now have your crater burned at a 55-degree angle and may mount in front of the hole a suitable lens and bit of mirror set to reflect the image to any desired point on the ceiling, floor or elsewhere. Having done this, strike the arc again, and before the crater has any time to change its angle, draw a line along the edge of the reflected image of the crater, wherever it may be. This line will represent the 55-degree angle of the crater, and by holding the crater image to the line you will have it burning efficiently.

Of course if your lamphouse already has some means of

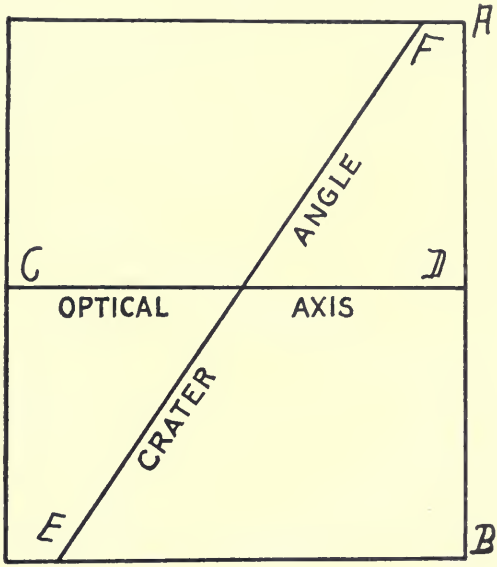


Figure 124.

projecting the crater image, it will act to modify the foregoing instructions. If there is a big hole covered with colored glass, it will be necessary to remove the glass, cover the hole with metal and then proceed as per the instructions.

NOTE.—*Since Blondel's experiments great improvements have been made in carbons, so that the c. p. per sq. mm. of projection carbon arcs is now nearer* 160 *than* 130. *We have therefore arbitrarily selected* 150 *as an approximation (rather under than over) of the sq. mm. candle power of projection carbon arcs.*—AUTHOR.

Resistance as Applied to the Projection Circuit

THERE is no difference in principle in resistance as applied to the projection circuit and in resistance as applied to any other circuit, but in practical application the differences are such that a somewhat extended explanation of resistance as applied to the projection circuit is necessary, particularly in view of the fact that the element of variable resistance enters very largely into the matter.

The projection circuit is supplied by a voltage which is presumed to be a fixed quantity. This may be anything from 50 to 500 volts, though ordinarily it is either 60, 70, 110 or 220. On the other hand the amperage necessary to projection under different conditions is an extremely variable quantity. In stereopticon projection it may be as low as 12 amperes. For the projection of motion pictures anything from 25 to 120 amperes may be required, 25 representing the minimum arc projection for theatrical work, and 120 the maximum amperage from which any gain in light may be had through the projection optical system as at present constituted. With a given supply voltage, 110 for example, taken from a power distribution system the resultant amperage at the arc will depend entirely upon the amount of resistance opposed to the current flow.

Before attempting to study resistance as applied to the projection circuit the student should gain a comprehensive

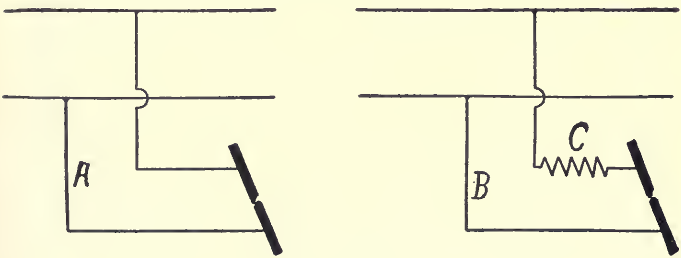


Figure 130.

understanding of the operation of resistance as applied to all electric circuits, which may be had from a study of the matter under the general heading "Resistance," Page 60.

When resistance is spoken of in connection with a projection circuit, what is meant is rheostatic resistance, or the resistance of the "rheostat," which consists either of a series of wire coils composed of high resistance wire (see "Properties of Resistance Metals," Page 67), or a series of cast iron grids, which are in effect wires made of cast iron. These coils or grids are mounted in a frame, from which they are completely insulated; they are also protected by a metal casing or covering, and in the case of the adjustable rheostat there is a dial switch by means of which a portion of the resistance may be either eliminated or put into use, at the will of the man in charge, as will be described.

In Fig. 130, at A, we see the diagrammatic representation of an arc lamp connected directly to the supply wires, without any rheostatic resistance interposed. Under this condition it will be readily understood that the instant the carbons are brought into contact a dead short circuit will be formed, which will blow a fuse. At B, Fig. 130, we see a similar lamp connected to the same supply wires, but with rheostatic resistance C connected in series with the arc. This resistance operates precisely the same as does any other resistance, such as, for instance, that of the filament of an incandescent lamp. Disregarding technicalities, the rheostat opposes sufficient resistance to allow the passage of a certain predetermined number of amperes, the number of amperes passing being dependent upon the supply voltage and the number of ohms resistance in the rheostat.

As has already been explained, however, on Page 56, this is only true so long as the carbons remain in contact with each other. With the carbons in contact the number of amperes flowing would be equal, roughly, to the supply voltage divided by the number of ohms resistance in the rheostat. The instant the carbons are separated, however, and an arc is struck, additional resistance is established in the arc itself, the amount of which will vary with the number of amperes flowing, see Page 400, so that the actual current flow will be equal to the applied voltage divided by the sum of the number of ohms resistance contained in the rheostat and the arc lamp circuit; this latter being, for practical purposes, disregarded.

The resistance of a projection arc is to all intents and purposes a fixed quantity for any given number of amperes, because the projection arc operates at its point of highest efficiency, both in the item of current consumption and in the item of light delivered, with a certain fixed separation of the carbons for each different current strength.

As has been remarked, the supply voltage of each theatre is presumed to be, and should be a fixed quantity. By this we mean the theatre is supplied with current the voltage of which is presumed to remain constant at a certain given pressure, say 110 volts. The projection arcs at one theatre may require 45 amperes D. C. and at another theatre 60 amperes D. C. How may this requirement be met, when both theatres have 110 volt current supply?

The answer is simple. The change in amperage is accomplished by varying the amount of resistance in rheostat C, diagram B, Fig. 130. This resistance may be made of sufficient amount to reduce the amperage to almost any desired quantity, or it may be slight enough to allow the passage of any number of amperes within the capacity of the wires and apparatus.

VARIABLE AND FIXED RESISTANCE.—There are two types of rheostat, namely, the "fixed resistance" and the

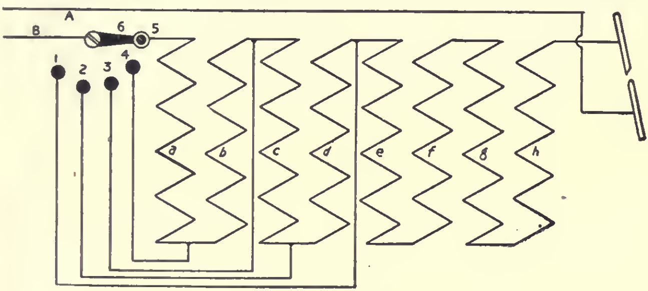


Figure 131.

"variable resistance." A fixed resistance rheostat is one in which no means is provided by the use of which the resistance it offers may be varied at the will of the man in charge. It consists of a number of coils of resistance wire, or a number of cast iron grids mounted in the usual way, with a binding post at either end of the resistance element, so that the current must pass through the entire resistance.

It is, however, not only possible, but the common practice to so construct rheostats that the amount of resistance supplied may be varied at will, merely by moving the lever of a dial switch attached to the rheostat, which, of course, has the effect of altering the number of amperes at the arc. Such an instrument is what is known as an adjustable rheostat. The principle of its operation is illustrated in Fig. 131, in which A-B are the supply lines, the rheostat in this instance being connected into line B, which is the positive. Line B connects to lever 6, which is the arm or the lever of dial switch; 1, 2, 3, 4 and 5 being its various contacts.

An examination of this diagram will show that with the

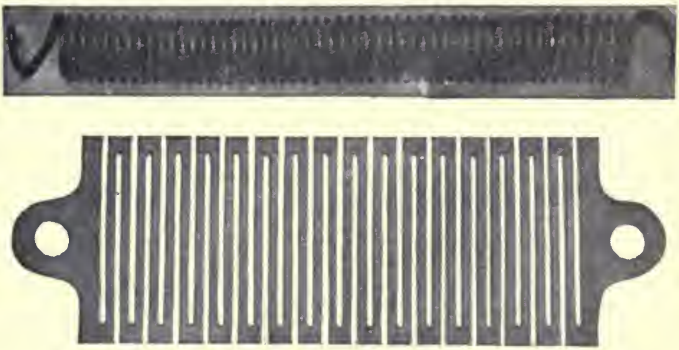


Figure 132.

lever on contact 5 the current must pass through the entire eight coils of the rheostat, hence with the lever in this position the rheostat is oppoing its maximum resistance to the supply voltage, therefore reducing the amperage to a minimum. Should we however move the lever to contact 4, it will be readily understood that the current will pass down wire 4, entering the resistance at the bottom of coil B, which has the effect of eliminating coil A and reducing the total resistance of the rheostat by whatever amount of resistance coil A supplies.

If lever 6 be on contact 3, then the resistance of both coils A and B will be eliminated. If the lever be on contact 2 then the resistance of coils A, B and C will be eliminated, and if the lever be on contact 1 then the resistance of coils A, B, C and D will be cut out, and we will only have remaining the resistance of coils E, F, G and H. The resistance of these last four coils is what is known as the "fixed resistance" of an adjustable rheostat. It is the amount of resistance which cannot be cut out by means of the adjusting switch. It must be sufficient to withstand the pressure of the supply voltage without overheating. In other words: **the fixed resistance of an adjustable rheostat must offer sufficient resistance to prevent enough current passing to overload the wires or grids composing the fixed resistance.**

In Fig. 132 we see the photographic representation of a rheostat coil and a rheostat grid. It will be observed that the grid is really the equivalent of the wire coil, except that it is made of cast iron.

There are several different kinds of rheostats, but the adjustable rheostat is the one now most largely used in projection work. Another type of rheostat which is semi-adjustable is made up of several separate fixed resistance cells or rheostats mounted in a single case, so that the amount of resistance delivered by the whole may be altered by changing the connections to include a greater or less number of the total number of cells. These rheostats were considerably used in the earlier days of projection, but have, for the most part, been discarded in favor of the more convenient adjustable rheostat.

HEATING.—A rheostat will continue to perform its office even though its coils or grids are red hot, but if worked under these conditions the life of the coils or grids will be very greatly shortened. Also when thus overloaded the temperature of the coils or grids may at any time reach a degree sufficient to fuse the metal, thus stopping all current flow and necessitating a somewhat difficult repair.

Rheostats should never be worked at high temperature. The heat in rheostat coils or grids should under no circumstances exceed 900 degrees F.

Of course the projectionist will not be in position to measure such high temperatures, but a temperature of 900 degrees is one which will cause the rheostat coils to become visible in a dark room. A dull red heat is approximately 1,300 degrees Fahrenheit, while a cherry red is 1,500 degrees. If you use your rheostat at such high temperatures as will make the coils show red in daylight it will not last long. As a matter of fact even the 900 degree temperature is too high for true economy. Five hundred degrees Fahrenheit is, everything considered, as high as your rheostat ought to operate, and if it is not allowed to exceed this temperature the life of the coils and grids will be very greatly prolonged.

In practice this means that if the coils are not allowed to reach a temperature which will make them visible in a dark room the rheostat will last many times longer than it will if the coils are operated at a temperature which will render them visible. The projectionist thus has a very good and practical check on rheostat capacity. If it is delivering satisfactory amperage and its coils cannot be seen in a dark room all is well. If when it is delivering the desired amperage it is found that the coils are visible in a dark room, then it will be true economy to cut down the amperage, if it is an adjustable rheostat, and add a second rheostat in multiple in order to get the desired current flow. If it is a fixed resistance rheostat it has not sufficient resistance, and resistance should be added as per Fig. 133.

As a matter of fact if exhibitors would install two rheostats working at less than capacity, instead of one working at full capacity, the general results would be very much better, and the two rheostats would last ten times as long as the single rheostat will when working at capacity.

RHEOSTAT REPAIR.—It is an excellent plan to have on hand a few extra rheostat coils or grids, so that repairs may be made by the projectionist in case a coil or grid burns in two or is broken. Making such repairs is, or should be, entirely within his capacity. The installation of a coil or grid requires only a little knowledge and careful work. The method of locating a grounded coil or a fault in the insulation is described on Page 358. The method of removing the grid or coil from the rheostat and replacing it with a new one will, of course, vary with different kinds of rheostats, but the principle is always the same.

The main thing to remember is that all coils or grids must be completely insulated from the supporting frame, and alternate ends of the coils or grids must be insulated from each other.

Remember that, no matter what the form of your rheostat may be, whether round, rectangular or square, whether of fixed or variable resistance, or whether of coils or iron grids, its electrical action is always precisely the same. The current enters at one end of a series of coils or grids and must pass through the entire length of each coil or grid consuming a portion of the voltage in the process of overcoming the resistance.

One point which is apt to puzzle the novice is that the voltage of the arc varies comparatively little, and if it be true that the voltage is reduced according to the amount of resistance in the rheostat, why is not the arc voltage varied more greatly when a portion of the rheostatic resistance is cut in or cut out?

The answer is simple. The resistance of the arc and the resistance of the rheostat are two entirely separate elements, and the resistance of the arc is dependent entirely upon the separation of the carbons and the kind and character of the arc stream. These elements are not in any way connected with the item of rheostatic resistance. No matter what the resistance of the rheostat may be, the resistance of the arc will be such as is set up by the conditions prevailing at the arc, which are dependent upon the elements just named.

INSULATE YOUR RHEOSTATS.—The rheostat as a whole should always be thoroughly insulated from ground. This may best be accomplished by placing the rheostat on a slate or marble shelf, but it may also be done by setting it on sheet asbestos, asbestos millboard or some other heat resisting insulating material.

Unless the rheostat be thus insulated from ground it is always possible that one of the coils may sag against the outer casing, or through some fault in the insulation become grounded to the frame of the rheostat, in which event if the rheostat as a whole be grounded there is likely to be current leakage. Such leakage may be sufficient to be immediately detected, but if the ground is one offering high resistance it is entirely possible the leakage may continue for an indefinite time without being discovered and every bit of current thus wasted will be registered on the meter. Should one of the coils sag against the casing, or should the coils become in any way grounded to the frame, and the support of the rheostat offer a path of comparatively low resistance to a wire of opposite polarity it is likely a fuse would blow.

All trouble of this kind is avoided by placing the rheostats on insulating material.

In the past is has been no uncommon thing to have a theatre manager complain of excessive current bills, only to find, upon investigation, the loss to be entirely due to leakage from the rheostats. In such cases the ground was of such high resistance that the leakage was not sufficient to either overheat the wires or blow the fuses, but it was of considerable amount, and the leakage was constant every moment the rheostat was in use.

WARNING.—Rheostats should never, under any conditions, be placed on an iron covered shelf, or on any other material connected with ground which will carry current in event of the resistance element becoming grounded to the frame of the rheostat. Always place rheostats ON NON-INFLAMMABLE INSULATING MATERIAL.

COOLING THE RHEOSTAT.—One excellent way of dissipating the heat generated by the rheostat and blowing it out of the room is to set the rheostat in front of an opening, in some location where it will be safe to remove the outer casing. Remove the outer casing and set a small fan in front of the coils or grids in such way that the blast from the fan will blow through them and blow the heat out of the room. This has the double advantage of getting rid of the objectionable heat and increasing the capacity of the rheostat. (Also see "New Rheostat," Page 437.)

LOCATION OF RHEOSTATS.—Rheostats become hot—sometimes very hot. It is therefore unsafe to locate them very close to any sort of inflammable material. Rheostats should never be located within less than one foot of any wall containing inflammable material unless a sheet of 3/8 inch asbestos be established between the rheostat and the wall, with at least a two inch air space between the asbestos and the wall. Rheostats should, of course, be thoroughly protected against any possible contact with inflammable substance of any kind.

As regards the location of rheostats in the individual projection room, so very much depends on the local condition that only general rules can be given. (a) Where it is practical it is always best to locate the rheostats outside the projection room. This is particularly true in warm climates. The projection room is likely to be more or less uncomfortably warm in summer, and if we add to the heat generated by the electric arcs and the natural heat of the weather the heat of anywhere from one to three rheostats, a very uncomfortable condition is likely to result. It is quite entirely possible to place an adjustable rheostat outside the projection room and so connect the lever of its dial switch by means of a series of levers and rods, or cords, as to enable the projectionist to alter the position of the dial switch at will from working position beside either projector.

If conditions make it necessary to locate the rheostats inside the projection room then they should preferably be located near the ceiling, and if possible under a vent leading directly to the open air.

If it is not practical to have such a vent from the rheostats to the open air, then a hood should be provided, with a pipe leading therefrom directly into the projection room vent flue, so that the heat generated by the rheostats will be carried away.

Under no circumstances should rheostats be located on or near the floor of a projection room. Such location will not only breed discomfort in warm weather but will be decidedly dangerous, because of possible contact with film or other inflammable material.

EXAMINING CONNECTIONS.—It is important that the binding posts of the rheostat be frequently and carefully examined. Metal oxidizes under the action of heat, and if the rheostat terminals be left too long without attention, a thin scale is apt to form between the wire or the lug and the metal of the binding post. This scale may be quite visible, or it may be practically invisible. In either event it offers very high resistance.

It is an excellent plan to loosen the terminal connections of the rheostat at stated intervals (the length of same to be dependent upon the number of hours per day they are in use) and clean them thoroughly, either by the use of sandpaper, emery cloth or by scraping. This is particularly important if the rheostat be working at or above capacity. Where rheostats are used several hours every day, once a week is none too often to do this.

ADDING EXTRA RESISTANCE.—Should your rheostat deliver too much current when all the resistance is "in," or if from any other cause you should desire to increase its resistance, you may do so by mounting one or more extra rheostat coils as per A, Fig. 133. It is also possible to introduce extra resistance in this way by making up some coils of No. 8 soft iron wire (or larger size if it be a rheostat of larger amperage capacity), though this is not recommended, since iron wire has a very high temperature coefficient.

The extra coils may be mounted on porcelain insulators, such as are used for mounting electric circuit wires. The ordinary porcelain knob insulators will do. These extra coils may be mounted on a brick wall or on a suitable iron frame, but they must not be placed near anything inflammable; they must also be protected by an outer casing the same as the regular rheostat coils. Wire screening having about ¼ inch mesh is suitable for protection. These coils may either be mounted near the rheostat, or at some distance from it, connection being made between them and the rheostat by means of a suitable size copper wire.

IRON WIRE RHEOSTATS.—It is possible to construct a rheostat from ordinary iron wire, but such wire has a very high temperature coefficient, which means that its resistance

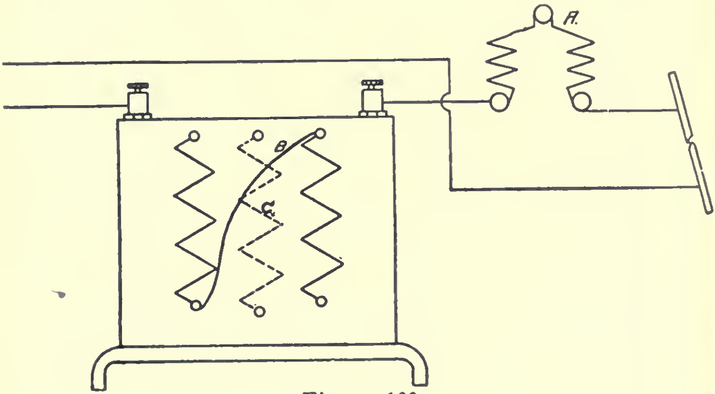


Figure 133.

increases rapidly with the increase of temperature. The result of this is that if you build an iron wire rheostat capable of delivering the amperage you want after it becomes hot, it will give altogether too much when you first strike the arc.

OBJECTION TO BIG GRID RHEOSTATS.—As has been said, the temperature coefficient of cast iron is high. This means that a cast iron conductor of given area will deliver very much more current when it is cold than when it is hot. This forms one of the objectionable features of the cast grid rheostat, but the objection is not serious when rheostats of small size are considered. When we come to consider the cast grid rheostat of large size, however, it presents a different aspect, because if it is made to give a certain given current flow when heated to working temperature there will be a tremendous rush of current when the arc is first struck and the grids are cold. Big cast iron rheostats should therefore have some means provided for cutting in extra resistance until the grids heat up.

The grid rheostat presents certain advantages, also certain disadvantages as set forth below:

Advantages.	Disadvantages.
(a) Better able to withstand high temperatures without damage.	(a) It is more difficult to replace broken grids than to replace coils.
(b) Grids are less likely to sag and become grounded to the casing than coils.	(b) The grid rheostat is much heavier than the coil rheostat of equal capacity.
(c) Grids give longer service than coils.	(c) Grids can be broken by a heavy jar.
(d) They deteriorate very slowly.	(d) Temperature coefficient low and less fixed, therefore the grid resistance is somewhat less reliable.

TEMPORARY REPAIR.—Should a coil or grid burn out it is quite possible to make a temporary repair as per Fig. 133, in which B is an asbestos covered No. 6 copper wire doubled, and C the broken coil. It is not necessary to describe the operation, because the illustration shows clearly how it is done. The reason for doubling the No. 6 copper is that it will be subjected to high temperature. Such a repair eliminates a single coil, but almost any rheostat used for projection purposes may be used temporarily with one of its coils cut out. It is, of course, understood that such a repair is only intended for strictly temporary use.

RHEOSTATS CONNECTIONS.—Rheostats may be connected into a projection circuit either singly, "in series" or "in multiple." The various series and multiple connections are perhaps one of the most puzzling things the novice has to contend with; also a large percentage of the "operators," and even some projectionists do not understand the matter any too well, yet it is quite simple.

Fig. 134 is the diagrammatic representation of what is known as the series connection. In this connection we find two 2-ohm rheostats connected in such way that the resistance of both is opposed to the voltage as a single element.

In other words, instead of 2-ohms resistance opposed to the voltage, as would be the case if we had but a single rheostat, 4-ohms resistance is opposed. Disregarding the resistance of the arc, if the supply current were 110 volts and we had but a single 2-ohm resistance rheostat connected in there would be a resultant current flow of 110 ÷ 2 = 55 amperes.

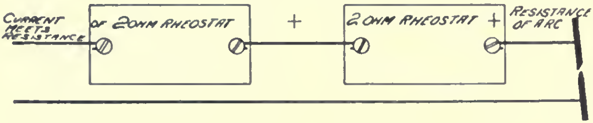


Figure 134.

If we now connect another 2-ohm rheostat in series as per Fig. 134, we will have 4 ohms opposed to the current, and, again disregarding the arc resistance, we would as a result have 110 ÷ 4 = 27.5+ amperes current flow. Please understand clearly that this would not be the result of the connection shown in Fig. 134, because in addition to the 4 ohms opposed by the rheostats there would be the resistance of the arc added thereto. In the above we are merely showing you the way the thing operates—not working out accurate results. The actual total resistance of such a combination, including the arc, would be about 5 ohms, hence the actual current flow 110 ÷ 5 = 22 amperes.

MULTIPLE CONNECTION.—The multiple connection is one which puzzles many, yet it is a very simple matter, once one gets a clear idea of the principles involved.

Fig. 135 is the diagrammatic representation of a water main, A, connected to the supply pipe B of a motor by means of two small pipes in which valves C-D are installed.

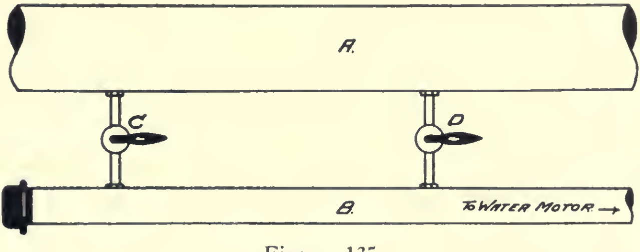


Figure 135.

The pressure in pipe A we will assume to be 110 pounds. If we open valve C, its full capacity will flow from pipe A into pipe B, and be used by the motor. Under this condition that is all the water the pressure in pipe A will be able to force through pipe C into pipe B. If pipe C were the only connection between pipes A and B, then the capacity of pipe C would be all the water which could possibly reach the motor.

In addition to pipe C, there is, however, pipe D. We open its valve and instantly the amount of water flowing into pipe B is doubled; also the power of the motor is doubled.

Precisely what water does in Fig. 135 the electric current does in a multiple rheostat connection.

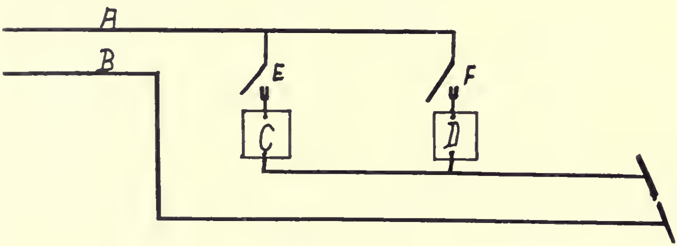


Figure 136.

In Fig. 136 we have precisely the same thing as applied to electrics. A and B are the wires of a projection circuit, C-D two rheostats and E-F two single pole knife switches. It requires no large understanding to see that if we close switch E the arc will receive amperage equally to the capacity of rheostat C. If we then close switch F the arc will in addition receive the capacity of rheostat D. This is what is known as a "multiple connection," which is again diagrammatically represented in Fig. 137, in which the connection is shown in two ways, the 25 ampere dotted line in A representing the resistance of the coils or grids. If you will carefully trace out the connections in diagrams A and B Fig. 137 you will find they represent precisely the same thing as the water pipe connection in Fig. 135 and the connection shown in Fig. 136.

Any number of rheostats of different type or different voltage may be connected in series, provided the total resistance of the whole be sufficient to reduce the current flow to a point where neither wires or resistance will be overloaded.

Any number of rheostats may be connected in multiple, provided each individual rheostat has sufficient resistance to oppose the line voltage without overload, and further provided that the resultant amperage be not great enough to overload the circuit wires, arc lamp or apparatus. For instance, a 10 ampere, a 50 ampere and a 25 ampere 110 volt rheostat may be connected in multiple on 110 volts. The result would be a current flow equal to the combined amperage capacity of the rheostats, or 10+50+25=85 amperes, hence the circuit wires etc. must have at least 85 amperes capacity.

You may use a 220 volt rheostat on 110 volts, or on any other voltage not in excess of 220. You would not, however,

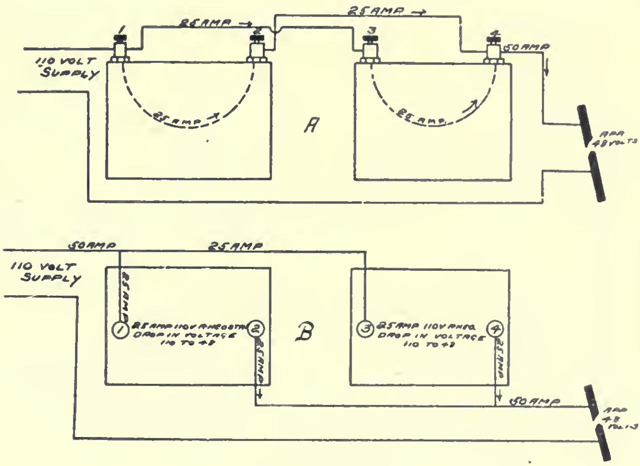


Figure 137.

get amperage equal to the rated capacity of the rheostat except on 220 volts. You cannot, however, connect 110 volt rheostats either singly or in multiple on 220 volts, because they have not sufficient resistance to withstand that pressure. If 110 volt rheostats were connected either singly or in multiple on 220 volts the coils or grids would get white hot and burn out very quickly. You may, however, connect two 110 volt rheostats in series on 220 volts, by reason of the fact that you would in effect be making one rheostat out of the two, thus presenting double the resistance required for 110 volts. Two 110 volt rheostats connected in series would, however, be slightly overloaded (we speak of rheostats made for use on a projection circuit) because of the fact that such rheostats are made to operate in conjunction with an arc, the resistance of which is figured in the total, so that if the arc produced one ohm resistance and the rheostat two ohms, then the total would be three ohms when connected singly, but when connected in series instead of having six ohms there would only be five, because the resistance of one arc would be absent.

You may use a rheostat built for a certain voltage on that voltage or on anything less than that voltage, but you cannot use a rheostat on a higher voltage than it is built to withstand, unless it be placed in series with additional resistance; though this latter is qualified to the extent that a rheostat built for a certain voltage may usually be used on current 5, 10 or even 15 volts in excess of that pressure.

A. C. and D. C. RHEOSTATS.—The novice often asks: What is the difference between an A. C. and a D. C. rheostat?

There is no such thing as an A. C. or D. C. rheostat. Any rheostat will work either on A. C. or D. C., but a rheostat which will deliver 30 amperes to a projection arc when connected to 110 volt D. C. supply wires, will deliver a somewhat higher amperage on the same voltage A. C. This is because of the fact that an A. C. projection arc is shorter, hence offers less resistance than the D. C. projection arc of equal amperage, therefore the total resistance opposed to the current by the rheostat and the arc is reduced.

This is, however, qualified by the fact that there is some tendency to inductive effect when a wire coil rheostat is used on A. C., which has the effect of adding inductive resistance, or in other words "magnetic kick" to the ordinary resistance offered. The amount of inductive restisance thus set up will vary with the size of the coils, their length and the spacing of the spirals. It amounts to something, though not very much. The inductive effect, however, does cause vibration in the coils, with the result that some wire coil rheostats are very noisy when used on A. C. This noise may be reduced by packing the center of the coils tightly with threaded asbestos forced in at the end of each coil.

The use of rheostats on alternating current is extremely bad practice. It is entirely unnecessary and very wasteful. Where alternating current is used, rheostats should be replaced with low voltage transformers, (see Page 544) or better still with a motor generator set (see Page 443) or mercury arc rectifier (see Page 515).

If, however, it is for any reason necessary to use resistance in A. C. projection circuits, we would by all means advise the use of the grid type, since they will be less noisy and there will be less inductive effect than with coil rheostats.

RHEOSTAT WASTEFUL.—The rheostat as applied to the projection circuit, is for the purpose of consuming the difference between line voltage and arc voltage. Put in electrical terms it is to "break down" the line voltage to the value of arc voltage. In still other words it is to reduce the voltage to the pressure necessary to force the desired number of amperes against the resistance of the arc.

This process represents an absolute waste of energy, since the difference between the line voltage and the arc voltage must be and is dissipated in the form of heat generated by the resistance, and since the heat cannot ordinarily be put to any practical use it follows that the energy consumed in its production is wasted, and the energy thus consumed is all registered on the meter, and must be paid for.

For example, let us assume a current supply of 110 volts and that we are using 40 amperes at the arc. Voltage multiplied by amperes equals watts, hence 110 × 40 = 4,400 watts registered by the meter. The voltage of a 40 ampere arc, using modern carbons, would be about 50 (see Page 395), hence the difference between 110 volts and 50 volts, which is 60 volts, must be consumed in the resistance element of the rheostat. It therefore follows that under this condition the waste in the rheostat will be equal to 60 volts × 40 amperes, 2,400 watts. We therefore are using a total of 4,400 watts, and only actually employing 4,400 — 2,400 = 2,000 watts in the production of light. Under this condition the rheostat is a little less than 46 per cent. efficient.

The condition just described is bad enough, but if the voltage be higher, as for instance 220, then the proportion of waste becomes literally enormous. Using 40 amperes from 220 volt lines through rheostats means a total consumption of 220 × 40 = 8,800 watts registered by the meter, whereas the actual wattage used at the arc is, as in the former case, 50 × 40 = 2,000, hence there is wasted in the resistance of the rheostat 8,800 — 2,000 = 6,800 watts, or about 3½ times as much energy as is actually employed in the production of light, and the rheostat is, under this condition, less than 23 per cent. efficient. On the other hand, if the voltage were only 60 or 70 then the waste in resistance would be correspondingly less.

Note: It may be observed that the resistance of an arc operating off 220 volt lines through a rheostat is higher, hence its wattage consumption is higher. This may be true but the total waste of energy is not affected by that fact.

Rheostats are only suitable for use on projection circuits where the supply is direct current and the voltage be such that the waste inherent in the rheostat is less than the waste inherent in a motor generator set. If the pressure be 220 or higher it will be very much more economical to break down the voltage by means of a motor generator set, and the efficiency of modern motor generator sets, or some of them, is such that it may pay to use them on 110 volt current, but in this we must consider the actual efficiency of a motor generator set and the fixed charge of the interest on the capital invested, as well as the deterioration of the machine itself. If these various items are such that there is not sufficient saving as against the rheostat to justify its installation and operation, it therefore follows that the rheostat, although enormously wasteful, is still the most economical thing available, everything considered.

If the current be A. C., then as we have already said, there is no excuse for using a rheostat, because either a motor generator set or a transformer is available, and of late years A. C. to D. C. motor generators have been invented which operate at arc voltage, without any resistance in series between the generator and the arc. Such sets work at maximum efficiency, and there is the added enormous advantage of having direct current at the arc. Also there is the mercury arc rectifier available, see Page 515. If for any reason it is deemed inexpedient to install a motor generator set, then a low voltage transformer (inductor, economizer, compensarc, etc.) may be used, and these devices are very much more efficient than the rheostat (their efficiency is well above 90 per cent. though they have the disadvantage of supplying alternating current to the arc. See Page 544.

RHEOSTAT CONNECTIONS AND RESULTANT AMPERAGE.—In Fig. 138 we see a 110-volt adjustable-grid rheostat, with part of its casing removed, and a Powers 110-volt non-adjustable coil rheostat. The grid rheostat has a 40-ampere maximum capacity, which may be reduced to 25 amperes by means of the dial switch. The Powers has a maximum capacity of 25 amperes, which cannot be changed. By tracing the connections and comparing them with Figs. 136 and 137 you will find that it is a multiple connection, so that we will get 25 amperes through the Powers and 25 to 40 through the grid, according to how the dial switch is adjusted. We will therefore have a total of from 25+25=50, to 25+40=65 amperes at the arc with this combination. Were we to connect the same two rheostats in series on D. C. the resultant current would be from 10 to 12+ amperes. It is figured as follows. The Powers is a 25-ampere 110 volt instrument, hence it has, roughly, (110—50)÷25=2½ ohms resistance. The grid, when working at 25 amperes, must have the same resistance, hence there will be a total of 2½+2½ ohms resistance when they are opposed to the voltage in series when the grid is delivering its minimum amperage. The resistance of the arc will be approximately two ohms, hence 110÷(2½+2½+2) will equal the amperage. This amounts to about 16 amperes. If the grid were set on the

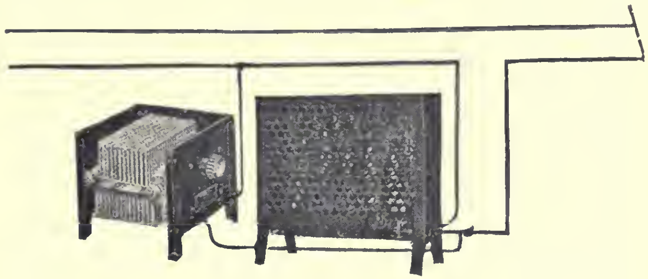
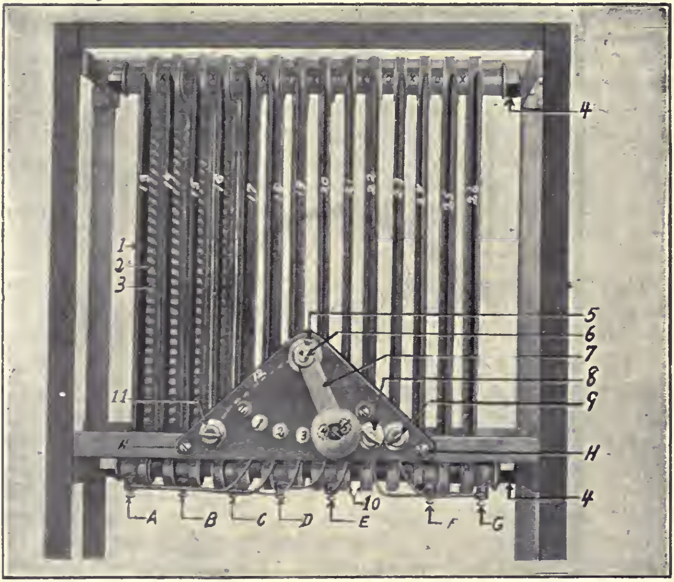


Figure 138.

40-ampere contact, we would then have (110—50)÷40= practically 1.5 ohms, which added to the resistance of the Powers makes 2½+1½=4 ohms. We would then have 110÷(2½+1½+2)=18+ amperes delivered. If the current were A. C. we would then have the same thing, except that instead of subtracting 50 from 110 we would subtract the resistance of the alternating current arc, which might be taken at about 30.

Our readers should understand, however, that these figures are approximate only. It is impossible to figure the matter accurately, for the reason that the arc resistance varies with the length of the arc, also the rheostatic resistance varies with (a) temperature of the coils or grids; (b) with their age; also merely because a rheostat is stamped "110 volt 25 ampere" it does not follow that it has exactly the resistance this would indicate. Then, too, the supply voltage may not be just what you think it is, hence it follows that **the results**



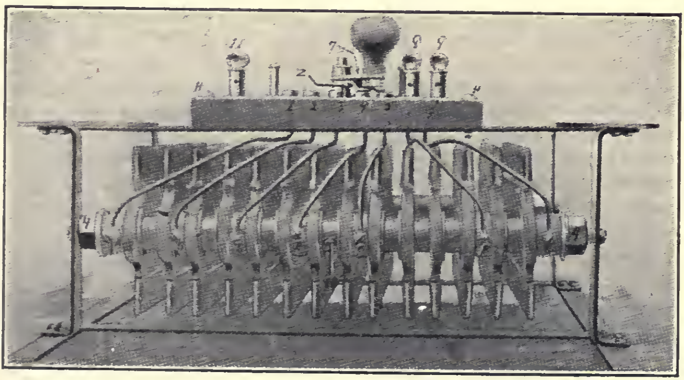


Figure 139.

obtained by figuring rheostat resistance will in the very nature of things be only roughly approximate.

As a matter of fact a wire coil rheostat rated at a given amperage, and which delivers that amperage when it is new, will not do so after it has been used for a time. The resistance of the wire coil rises gradually for a time, after which it remains practically stationary until the coils finally give out entirely. When the resistance reaches its highest point it will usually be found that the actual delivery of the rheostat will be from 5 to 10 per cent. less than the rated delivery.

This latter may or may not apply to any considerable extent to cast iron grids. It is claimed that the resistance of cast iron remains practically constant. We have been unable to secure reliable data substantiating the claim.

ADJUSTABLE RHEOSTAT AS IT IS.—In Fig. 132 we have the photographic representation of the single grid of a grid rheostat, and the photographic representation of the single coil of a wire coil rheostat. At the top in Fig. 139 we have a side and bottom view of a grid rheostat, the grids of which are numbered consecutively from 13 to 26. This particular rheostat is out of date, but it serves very well to illustrate what we have in mind. It will be observed that between each grid at the top is a spacing washer. These washers are alternately lettered X and O. The X washers are current carrying (metal) and form an electrical connection between two adjoining grids. The spacing washers, O, are of insulating material. They insulate adjoining grids between which they are placed from each other at that end. The nut on the end of the long bolt which clamp the whole thing together is numbered 4. This bolt is insulated from the metal of the grids. At the bottom is a similar bolt, also numbered 4 and also insulated from the grids. At the bottom of the grids are similar spacing washers, but if there is a metal spacing (X) washer (current carrying) between two grids at the top there will be an O (insulating) spacing washer between the same two grids at the bottom.

Examining this arrangement in detail we see that, starting at the bottom of the left hand outside grid the current passes up through the "wires" of the grid (a grid is, as you will see in Fig. 132, really nothing but a cast iron wire) to the top, through washer X into the second grid, down through this grid, through the current carrying washer between it and the third grid, up the third grid, across the current carrying washer into the fourth grid, down which it flows, and so on through all the grids.

The connections of such a rheostat are as follows: 11, 8 and 9 are the binding posts. Usually there are but two, but in this case there are three. The reason for the third post will be explained further along. Between binding post 11 and post 6 of the dial switch is a copper wire connection indicated by dotted line 12. The current passes from binding post 11 along this wire to post 6 of the dial switch, along lever 7 of the dial switch and into the contact the lever of the dial switch is on at the time, whence it flows into the grids of the rheostat as follows: If the dial switch is on contact 1 (the left-hand contact) the current will flow through the switch, through contact 1, into and along the

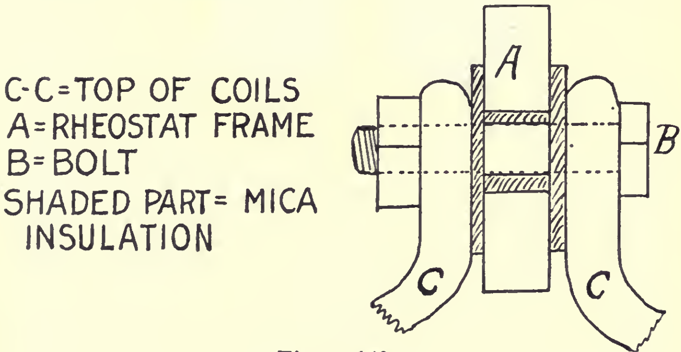


Figure 140.

wire into binding post A, which connects with grid one, whence it must follow its appointed path through all the grids, if the other wire is connected to binding post 9, which connects with the bottom of the right hand grid at binding post G. Binding post 9 is for use on the voltage the rheostat is designed for. Binding post 8 is designed for use where the voltage of the current is a little lower than the rheostat is supposed to be used on, for instance, 100 instead of 110. It connects, as will be seen, with binding post F. If the connection be made to binding post 8 it has the effect of permanently eliminating the two right-hand grids, thus lowering the value of the fixed resistance of the rheostat.

Suppose the switch is on contact 1 and the projectionist desires to increase his amperage. He moves the switch to the right to contact 2. The wire from contact 2 connecting to binding post B which, as you will see, operates to "cut out" the two left-hand grids, thus reducing the resistance of the rheostat as a whole. Contacts 3, 4 and 5 of the dial switch connect respectively to binding post C, D and E. The whole thing is diagrammatically represented in Fig. 131.

In order to disassemble a rheostat of this type one must

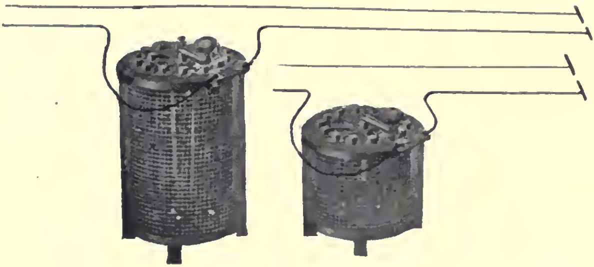


Figure 141.

first remove the outer casing, which is held to the frame by a number of screws, then the wires connecting to binding post A, B, C, D, E, F and G should be disconnected and a properly marked tag tied to each, so that no mistake will be made in reassembling. The dial switchboard may then be taken off by removing screws H-H. Following this the whole grid bank must be removed from the frame, and nuts 4-4 be removed, after which the grids may be disassembled, but great care should be taken not to injure the insulation.

The projectionist will do well before disassembling a grid rheostat to have at least one new insulating barrel for bolt 4, and some new insulating spacing washers.

The fixed resistance grid rheostat offers no different problem of construction, except that the dial switch and its connections are absent. The grids are insulated from each other in precisely the same way, binding post A-G being the only two such a rheostat will have.

At the bottom in Fig. 139 we have a view of the bottom of the rheostat shown above. Such a rheostat may or may not have the sides of its individual grids supported by a stiffener, which is made of sheet steel lined with asbestos and is slipped on the side of the grid to strengthen the grid.

At Z in the lower half of Fig. 139 we see the spring contact of the dial switch. It is esential that spring Z make good electrical contact with contacts 1, 2, 3, 4 and 5. This spring should have the attention of the projectionist occasionally, since it is subject to some heat and the tendency of the contact is to weaken. Its pressure may be increased by bending the spring. It is important that the face of the spring and the face of the contacts be kept smooth and perfectly clean, by occasionally polishing with No. 00 sandpaper.

DISASSEMBLING WIRE COIL RHEOSTATS.—While mechanical methods may differ, the general method of insulation and the principle involved is clearly shown in Fig. 140. The upper and lower ends of coils a, b, c, d, etc., Fig. 131, are joined together, and by the same means are bound to the supporting frame, as shown in Fig. 140. To release any one coil it is only necessary to remove bolt B, which holds its top, and a similar bolt which holds its lower end, but before re-assembling be very sure you have not disturbed the insulation, or if you have, that you have re-established it in perfect condition.

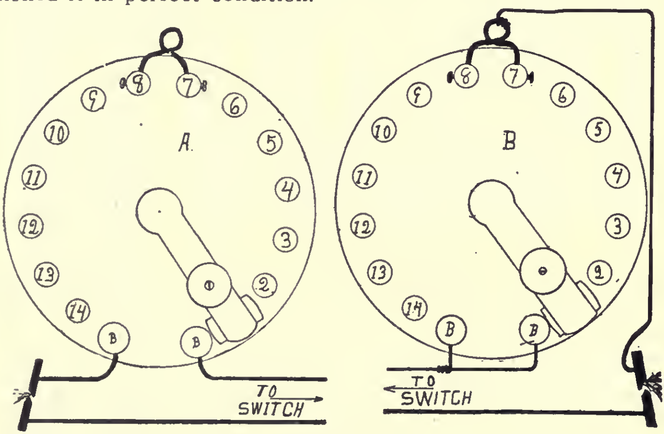


Figure 142.

CAUTION.—You may find the actual mechanical means employed to join and support the coils, and to insulate them from the frame, to be different from that illustrated in Fig. 140, but be assured it is a mechanical difference only. The actual thing accomplished is precisely the same as that shown, viz.: the coil ends are electrically joined, and in such way that they are bound to and supported by the frame, also they are thoroughly insulated from the frame, either by mica or asbestos, usually the former.

RHEOSTATS FOR ROAD USE.—As between the grid and wire coil rheostat we would advise the wire coil for road use. This advice is based on the fact that by comparison the wire coil rheostat of given capacity is very much lighter in weight, little if any more bulky, and is much less liable to damage through heavy jars. For road use the Nicholas Power Company puts out the wire coil rheostat illustrated in Fig. 141. This rheostat is made in two sizes, the smaller designed for 110 volts or less, while the large size may be

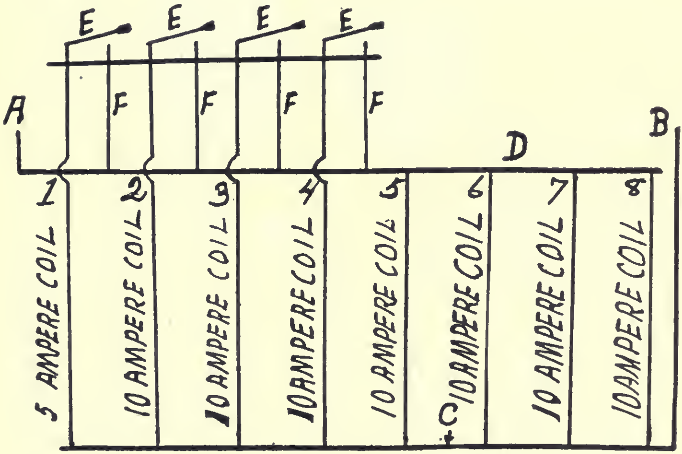


Figure 143.

used on any voltage up to 240. Both these instruments are adjustable. The 240 volt rheostat is quite flexible, in that it consists of two separate and distinct banks of coils, connected by a jumper as per Fig. 142, either or both of which may be used separately, or the two may be connected in series or in multiple.

Fig. 142 is the diagrammatic representation of this rheostat connected in two ways. The position of the adjusting lever in A places the two banks of resistance in series for use on 240 volts. The dial switch post in the center is connected directly with right hand binding post by means of a copper wire. As the lever is in diagram A, Fig. 142, the current enters one binding post, the right-hand one we will assume, passes through the dial switch lever and from it into contact No. 1, which connects with one end of the coil banks. It passes through all the coils of the right hand bank, through the jumper and through all the coils of the left hand bank, whence it passes to the arc, the end of the last coil (14) connecting to left hand binding post. This places the two sides of the rheostat in series and makes it available for use on current up to 240 volts pressure. In diagram B, Fig. 142, we see the two banks connected to the arc in multiple, the circuit wire being connected to the jumper, as shown, so that each of the two banks of coils become in effect a separate rheostat, as per Figs. 137 and 138. This method is, of course, not available for more than 110-volt pressure. By its use we get the full capacity of the two banks of coils. When using either one of the connections shown at A or B, Fig. 142, the lever must be placed on contact 1, though unless the coils show red with the lever on contact 1 it may be moved to contact 2, 3, etc., until the coils begin to show red in a dark room, to increase current flow. Of course, in practice, the wire would not be actually connected to the jumper, as in B, but branched, with one branch connected to each binding post, the jumper being removed.

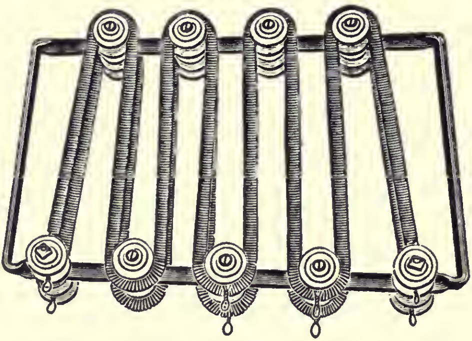


Figure 144.

In considering the selection of a rheostat for road use we would suggest that you investigate the merits of "New Rheostat," a description of which follows.

All projector manufacturers carry rheostats of standard size in stock, and can provide rheostats of special design or capacity on short notice.

NEW RHEOSTAT.—In 1921 a new resistance unit which is ideal for projection work came on the market, the general plan of which is diagrammatically outlined in Fig. 143, in which only the layout of the electrical parts, is illustrated, with the casing, supporting frame, etc., omitted. In the diagram, A and B are the main binding posts of the rheostat. C and D are two copper bus bars. E E E E are switches, which may be either single pole knife-switches, or a dial switch. Line G merely represents the slab of insulating material which supports the switches. F F F F are conductors which connect one terminal of switches E E E E with bus bar D. The four straight lines, 5, 6, 7 and 8, connecting the right hand end of bus bars C and D, each represent a single coil of resistance wire having a capacity of, in this instance, 10 amperes. In this particular diagram, these four coils represent the fixed resistance offered by the rheostat when switches E E E E are open. The next three lines, 2, 3 and 4, represent 10 ampere coils, each of which connect with one of the binding posts of a switch, as shown. With these three switches closed, the rheostat would deliver 40+30=70 amperes. The next line, 1, represents a 5-ampere resistance coil, which also connects to a switch. With all four of the switches closed the rheostat would deliver 40+30+5=75 amperes. The advantage of the 5-ampere coil is that by its manipulation the rheostat would deliver anything from 40 amperes to its capacity, in 5 ampere steps.

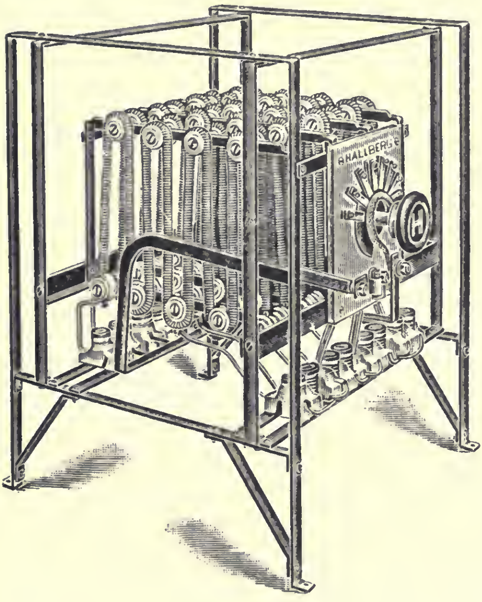


Figure 145.

In Fig. 144, two of the coils are shown, and the method of their mounting is illustrated. To replace these coils it is only necessary to release them from the end insulator and stretch a new coil around over the insulators. The frame in Fig. 144 carries two coils, one on either side. The insulators are of porcelain.

In Fig. 145 we see the general construction of one type of these rheostats illustrated, its cover cut in two, and in Fig. 146 another, the protecting cover being entirely removed.

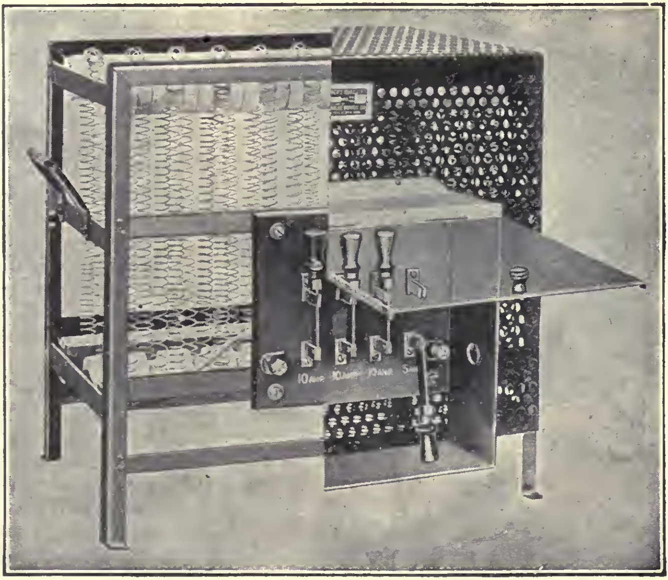


Figure 146.

In Fig. 147 a type of cover is shown which is to be heartily commended. It provides for connecting the rheostat cover to the vent pipe, or to the outer air, by means of a pipe, thus carrying practically all the heat generated by the rheostat out of the projection room. In the rheostat illustrated in Fig. 145 the coils are controlled by a dial switch; also each individual coil is protected by a plug fuse. This has the advantage that by removing any one of the fuses one coil is cut out of service and the capacity of the rheostat reduced by that amount. Also, of course, if there is trouble in any one individual coil the fuse will blow, thus automatically cutting the coil out of service without injuring any other coil, or affecting the rheostat as a whole, except that its capacity will be reduced by that amount.

Let it be clearly understood that any number of coils, or coils of any desired capacity may be used. Also any number of coils may be controlled, either by individual knife switches or by a dial switch, so that it is quite possible to have a rheostat with a minimum capacity of 5 amperes, and a maximum capacity up to anything the supply wires will carry.

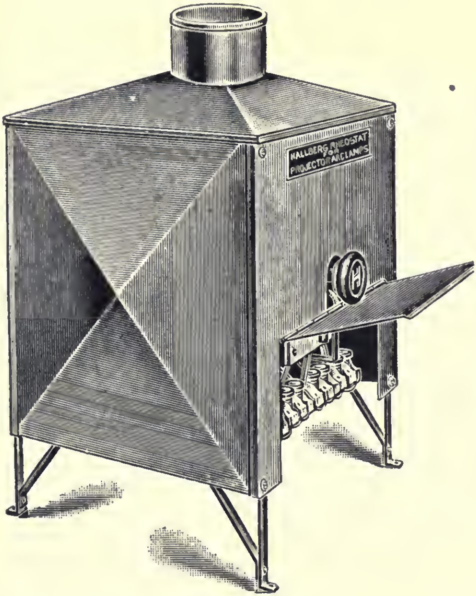


Figure 147.

Another advantage is that a rheostat of more than the desired capacity may be ordered, and one or more of the coils left idle, so that in case of accident to one of the coils it is only necessary to cut in an idle coil in order to instantly restore the rheostat to its normal capacity, and thus permitting of repair being made at leisure.

The rheostats are very light, electrically very flexible and are very well ventilated indeed. They are ideal for either road or theatre use. They have our hearty endorsement and approval.

As an afterthought we might add that in this type of rheostat each coil is, in effect, a separate, individual rheostat in itself, which amounts to having a number of 10 ampere rheostats, and one 5-ampere rheostat connected together in multiple, as will be observed by examining Fig. 143.

ASK YOURSELF THIS QUESTION, BROTHER: AM I ONE HUNDRED PERCENT. EFFICIENT, OR AM I A BULL ARTIST AND A "FOUR-FLUSHER"?

Current Rectification

ONLY about 65 per cent. of the theatres of the United States and Canada have an available direct current supply. The rest have A. C. supply only. We are not sufficiently conversant with the situation in this respect with regard to other countries in which this book is used to attempt an approximation of the percentage of theatres having A. C. supply only, but no theatres anywhere have a current supply the voltage of which is suitable for use at the arc.

It is a well-known fact that an alternating current projection arc is not only very much more difficult to handle, but also is likely to be more or less noisy (though special A. C. carbons have largely reduced the element of noise) also that very nearly double the amperage is required at the arc to secure an effect equal to a direct current projection arc. In other words, to equal the effect of a 40-ampere D. C. projection arc, an A. C. arc operating at about 80 amperes would be necessary. Why this is so is explained on Page 390.

Due to these facts, the almost universal modern practice in large theatres, and the very general practice in smaller theatres, is to "rectify" the alternating current supply (change it to D. C. and to arc voltage) either by means of a motor-generator set or a mercury arc rectifier, either of which receives alternating current from the line and delivers direct current at the arc, in most cases at arc voltage. These machines have been brought to such a state of perfection with regard to mechanical construction, efficiency, operation and ease of manipulation, that there is now absolutely no legitimate excuse for the continued use of alternating current at the projection arc. True, the exhibitor may offer in excuse the fact that the installation cost of the motor-generator or mercury arc rectifier, plus the item of deterioration, is a considerable sum, but this in fact is no excuse at all, because he will get all that and very much more besides back in increased patronage of the box office by reason of improved screen results.

This latter is, of course, in a few instances modified by the fact that there is an occasional projectionist who is sufficiently expert in the handling of the alternating current arc to produce results very nearly equal to the direct current arc. This, however, does not hold good to any considerable extent, and broadly speaking does not in the least invalidate our former statement.

The Projection Department of Moving Picture World and the author of this work unqualifiedly recommend the installation of either a motor generator set, or a mercury arc rectifier, with the notation that modern practice favors the motor generator set as against the mercury arc rectifier, because of the fact that the motor generator is a very much more flexible machine. The motor generator may be temporarily overloaded by as much as 100 per cent., though, of course, such an overload could only be maintained for a moment or two—sufficient time, however, for change-over—whereas the mercury arc rectifier cannot be overloaded to any considerable extent; also the motor generator may be had in any desired capacity, whereas the mercury arc rectifier is not made in anything exceeding 50 amperes capacity.

Let it be clearly understood that we do not recommend the overloading of a motor generator by 100 per cent., even for a short time, but such a machine should carry a 50 or even a 75 per cent. overload for as much as three minutes, with reasonable frequency, without sustaining injury.

MOTOR GENERATORS.—In the ordinary acceptance of the term as applied to projection, the motor generator is nothing more or less than an alternating current motor, of suitable voltage, cycle and phase to operate on the available supply, direct coupled to a direct current dynamo, the latter, in latest and best practice, being of the constant current type, i. e., wound to deliver an approximately steady amperage at considerable variation in arc voltage.

In fact the latter phase of the matter has been carried to such an extent that arc voltage may be doubled without appreciably altering the amperage. The latest practice is the motor generator, the dynamo of which is so wound that when it is "pulling" one projection arc, a second can be cut in series with the first, whereupon the voltage of the dynamo doubles, the amperage remaining constant.

The advantage of this type is that with a minimum effort on the part of the projectionist the change-over may be made without the slightest evidence of the act on the screen. This is by reason of the fact that with the arcs operating in series, in the very nature of things both of them must and will have precisely the same amperage, and if the adjustment of both, as regards distance from collector lens and angle of crater, be the same, and the optical train be identical, the screen illumination from each must and will have precisely the same value.

Another plan which has merit is that of the motor generator having a 70-volt dynamo using ballast resistance to reduce the generator voltage to arc voltage. The waste involved is very slight and the plan has its advantages.

D. C. to D. C. SETS.—There is a special motor generator set made, known as the "D. C. to D. C. motor generator," which operates, in effect, merely to reduce the voltage. (See Pages 466, 468 and 486.

GENERAL INSTRUCTIONS ON MOTOR GENERATORS.—In the interest of economy of space we shall give certain instructions which apply alike to all motor generators. To incorporate these in the matter covering each individual machine would merely be a reiteration of the same thing several times.

WARNING.—Exhibitors often complain to the author that their motor generator set is not as efficient as was claimed by the manufacturer. This may very easily be true without any fault on the part of the maker, for while a machine in perfect condition may show high efficiency, after a few months of unintelligent handling, or abuse, it may show something very different. Factory efficiency tests are made with machines in the very pink of condition. They naturally show very much higher than after a few months under the care of a careless or slovenly attendant, or one who knows very little and perhaps cares less beyond how to start and stop them, and to put fresh oil in the oil wells "once in a while." Loose connections, dirty brushes and roughened commutators do **not** make for efficiency.

GENERAL INSTRUCTIONS NO. 1, LOCATION.—Several things must be given very careful attention when the location for a motor generator is considered.

If it be practical it is decidedly better to locate the motor generator in a room directly adjoining and connecting with the projection room. If this is not a practical thing to do, then it may even be located within the projection room itself.

A basement location is, for several reasons, objectionable, and if the basement be damp and dark it should not be considered at all. Where there is dampness, the insulation of the wires will absorb more or less moisture while the machine is idle. This moisture will be expelled rapidly when the machine warms up, and this, many times repeated, is more than likely to do harm. It may, in time, entirely ruin the armature and field coils, which would compel the rebuilding of the entire electrical part of the machine. Another serious objection to this location is that in case anything goes wrong it takes a very much longer time to investigate and make necessary adjustments or repairs than would be necessary were the machine located either in the projection room, or in a room adjoining and connecting therewith. Then, too, a dark basement (or other location) compels the making of all repairs and performing other necessary operations entirely by artificial light, which is to some extent objectionable. **Another very, very serious** objection with many basements is that when the furnace is going there will be more or less coal and ash dust in the air, which is bound to get into the machine, and in course of time do irreparable injury thereto.

But after all, the most serious objection of all is the fact that the machine will be more or less inaccessible to the projectionist and will therefore be neglected. It most emphatically will not receive the daily attention it ought to receive. Common sense should tell anyone that a machine which is conveniently located and easily accessible will receive more and better attention than if it be located at a distance and a more or less inaccessible place. Common sense should also tell anyone that lack of necessary attention means increased deterioration in the machine itself. In other words the machine which has proper attention will operate with greater efficiency and last much longer than one which does not receive proper attention.

The only legitimate objection to locating machines of this kind in or adjoining the projection room lies in the possibility of vibration and noise, or in the weakness of the floor. We may, however, dispose of the latter by saying that any floor too weak to carry a machine of this kind is entirely unfit to be the floor of a projection room. As to the matter of vibration, it has, to all intents and purposes, been eliminated in modern machines of this type and such vibrations as remains can be entirely absorbed by means of a felt, cork or rubber mat, as per instructions under "Installation."

GENERAL INSTRUCTIONS NO. 2—INSTALLATION.— Upon receipt of a new motor generator the name plate should be carefully inspected. If it be a D. C. to D. C. machine it is only necessary to make sure that the voltage marked on the name plate corresponds with the voltage of the supply. If it be an A. C. to D. C. set it is then necessary to make sure the volts, the cycles and the phase of the motor agree with those of the circuit to which it will be connected.

The name plate on the generator should indicate its maximum capacity. If the machine is to be located in a basement, or at any other place a considerable distance from the projection room, the projectionist should make sure that the circuits leading from the generator to the projection room, and from the main house switchboard to the motor are both large enough to carry the maximum current they will be called upon to carry with, not to exceed a two-volt, or at most a three-volt drop. (See Page 74.)

If the generator is to be located in a basement it is an excellent plan to place it on a foundation raised at least 12, and preferably 24 inches from the floor. This is particularly important if there is danger of the basement flooding, or if the floor is wet, though in either of the latter events it would be sheer folly to locate a motor generator set in the basement.

DROP LIGHT.—No matter where the machine is located there should be a drop light hung over it, with sufficient slack cord to admit of the light being carried to any part of the machine. This latter is especially important if the machine be located in a dark place, such as a basement.

GROUNDING THE FRAME.—The frame of the machine should be thoroughly grounded by means of a copper wire, one end of which must make good electrical contact with the frame and the other end with a water pipe or the earth, as per instructions, Page 346.

REMOVING SUB-BASE.—If the machine is mounted on a sub-base, which for any reason it is desired to dispense with, it is highly important that the base which will receive the machine be perfectly level, and that the motor and the generator be carefully lined with each other. If this latter be not perfectly accomplished there will be an undue, and possibly a heavy strain on the coupling between the two shafts. Imperfect lining of the motor and generator is likely to result in noise and vibration; it certainly will cause rapid wear of the bearings of both the motor and generator. Machines in which the armature of the motor and generator are mounted on one shaft, with but three bearings and with no coupling between the two armatures, should under no circumstances be installed without their sub-base, if they be of the type which uses a sub-base.

Where a motor and generator are carried on a single sub-base or base, it is not necessary that they be bolted to the floor, nor is it necessary to build any special foundation for them.

CORK, FELT OR RUBBER.—Motor generator sets in which both elements are carried on a single base or sub-base require no base, but between them and the floor should be one of three things, viz.: a thick pad of cork, a thick pad of felt or a thick pad of fairly resilient rubber. These pads serve two purposes. They absorb any possible vibration, which would otherwise be communicated to the floor, and they serve to deaden the noise of the machine.

Cork is best, but the pad should be two or three inches thick. It need not extend all the way under the machine if the machine be of the horizontal type. If it be of the vertical type it will be just as well to use a pad or mat the full size of the machine, and two or three inches more. If the pad be of felt it should be of the kind ½ to one inch thick, and four or five thicknesses should be used. We can give no advice with regard to the rubber pad, because it will depend upon the kind of rubber you are able to get, but in any event a sufficient thickness should be used to absorb all the vibration.

It is imperatively necessary that the armature of horizontal type motor generator sets be perfectly level endwise, else it will not "float" (have end play), and failure to float will probably produce grooved bearings and commutator. For this reason it is necessary, after the machine has been set on its pad for a week, that it be tested, and if necessary levelled by slipping sheets of paper or metal under the low end.

CAUTION.—In the case of motor generators the armatures of which are joined by a coupling and which are not mounted on a single, rigid iron base, the pad method does not apply. Such machines must be bolted down to a solid, rigid foundation, the top of which is, of course, perfectly level.

ELECTRICAL CONNECTIONS.—Wiring diagrams and instructions should accompany each machine. It is hardly to be expected that the projectionist will be able to make the electrical connections for a motor generator, since there not only are several different makes, but more than one type of some makes; also there are single two and three-phase current complications. It is, therefore, to be expected that the electrical connections of the machine will be made by a competent electrician.

FINAL PREPARATIONS FOR STARTING.—After the machine is installed and the electrical connections complete, before starting, revolve the armature by hand and see that it moves freely. Examine the armature and commutator carefully to see that they are not bruised and that everything is in good condition. Examine the face of the brushes and test the brush tension. (See General Instruction No. 7.) Let the oil out of the oil wells and fill them up with fresh oil. (See General Instruction No. 3.) Having taken these precautions, the machine is ready to be tested with current.

CENTRAL INSTRUCTION NO. 3—OIL.—It may be stated as a general proposition that the various largely advertised patent oils are absolutely unfit for motor or generator lubrication. If they be used it is more than likely that there will be trouble with the bearings, or a comparatively frequent and unnecessary expense for bearing renewals, in addition to which there will be a still more serious item, viz.: worn journals.

The character of the oil to be used will depend to a considerable extent upon climatic conditions, but it is safe to say that **the oil used by the local power plant for lubricating its generators will fill the bill.** The superintendent of the plant will undoubtedly extend the courtesy of telling you what it

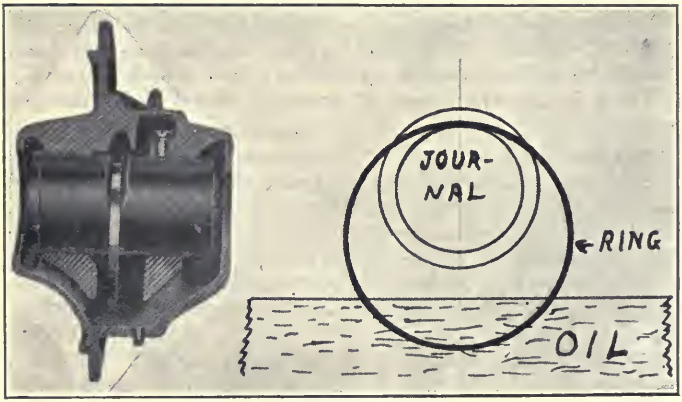


Figure 148.

is; also he probably will be willing to sell you a five gallon can at reasonable figures, and a five gallon can should last a long time. If you are able to procure the power plant oil you certainly cannot do better, because oil used to lubricate the heavy generators of a power plant must, in the very nature of things, be a good lubricant, and one suitable for use on motors and generators.

If you are unable to procure the oil used by the local power plant, then we would recommend for summer use a medium heavy dynamo oil, which may be used the year round if the motor generator be located in a room that is kept warm. If, however, the machine is in an unheated place, then in winter time a light dynamo oil will give the best general satisfaction.

BALL BEARING MACHINES.—Some machines are fitted with ball bearings, in which case provision is usually made for the use of either oil or grease. The amount of oil or grease required by a ball bearing is very little, its function being more to keep the races and balls free from rust than to actually lubricate them.

It is imperatively essential that only a lubricant containing no acid be used with ball bearings. An oil containing, for instance, animal fat, will finally roughen the polished surface of the balls or races and bring about the final destruction of the bearing. For this reason it is very much better that the suggestion of the manufacturer of the machine be implicitly followed in the matter of selecting a lubricant for its ball bearings.

CAUTION.—Most, if not all, motor generator sets of the horizontal type have the oil carried up to the journals by means of rings which rest on the journal and revolve merely by the friction of their own weight thereon. This type of bearing is illustrated in Fig. 148, in which we see an oil ring, the lower part of which runs through the oil well below the journal, the upper part resting on the top of the armature shaft, provision being made for this by a slot or groove cut in the babbit bearing. At the left it is shown photographically and at the right diagrammatically. You may understand the action of the ring by placing an ordinary iron ring on a short piece of iron pipe considerably smaller than the ring and revolving the pipe. You will see that the ring also revolves, though very much slower than does the pipe.

Once the action of this kind of an oil arrangement is understood, two things will be plain, viz.: first, since the lower half of the ring is immersed in oil, oil will be continually carried up to the journal by the ring. Second, if the weather be cold and the oil be stiff, then the friction of the journal may not be sufficient to revolve the ring, hence the journal will receive no lubrication until it has heated up sufficiently to melt the oil. For this reason a too-heavy oil must not be used in winter if the machine is located in a cold room.

CAUTION.—Be sure your oil is free from dust or sediment. Never leave an oil receptacle standing open. If you do it will collect dust and its lubricating quality will be greatly impaired. **Dirty oil very frequently is the cause of trouble in bearings, and in any event it wears bearings very fast.**

GENERAL INSTRUCTION NO. 4—CLEANLINESS.—It is important that all parts of motor generators be kept scrupulously clean. Oil should not, under any circumstances, be allowed to collect either on the machine or on the floor near it, and the machine should be kept free from dust. A medium size hand bellows will be found very convenient for removing dust from the armature, from around the pole pieces and in other inaccessible places. **A dirty machine is evidence of a lazy, indifferent or incompetent attendant.**

GENERAL INSTRUCTION NO. 5—LOOSE CONNECTIONS.—It is highly important that all electrical connections and all bolts and nuts be inspected periodically and tightened up, and all electrical connections be kept not only tight, but perfectly clean. **Loose connections are a continual source of unnecessary trouble.**

GENERAL INSTRUCTION NO. 6—AMMETER AND VOLTMETER.—Motor generators are, or should be, provided with both an ammeter and voltmeter, which instruments, in order to serve their best purpose, must be located within view of the projectionist when he is in working position beside the projector. **These instruments should be constantly under the eye of the projectionist.** It is a serious mistake to locate them where they cannot be read easily and continually observed, because there are certain points at which the arc furnishes maximum illumination with minimum current consumption, and if the ammeter and voltmeter be located within plain view of the projectionist, preferably on the front wall of the projection room, near the left hand projector observation port, the projectionist is very much more likely to handle his arc efficiently. This is especially true if the arc be hand fed.

GENERAL INSTRUCTION NO. 7—CARE OF THE COMMUTATOR.—The commutator of a D. C. motor or generator should require very little attention, but sometimes it does require a great deal.

The best evidence that the commutator is in first-class condition is a sort of glazed appearance, smooth as glass, a rather dark brownish shade in color, and a slight squeak from the carbon brushes when the armature is revolved slowly. To obtain and maintain this condition the following care is essential:

(a) Brushes, set as nearly as possible at the sparkless point, which point may, with the old style generator lacking the inter or "commutator" pole, vary with the load. On the newer type generator the inter or commutating pole is used, and the manufacturer marks the point at which the brush yoke should be set by making either a chisel or a center-punch mark on the yoke and on the frame. Some manufacturers fill these marks with white paint so that they are very easily seen; some do not. **If these marks are present the brush yoke should always be set so that the marks on the frame casting and on the yoke coincide or, in other words, are opposite each other.**

(b) The brushes must have sufficient tension to make good electrical contact with the commutator, **remembering that every particle of unnecessary pressure will tend to unduly wear both commutator and brushes.**

(c) The commutator should be kept clean and free from dust. This may best be accomplished by cleaning the whole machine every day, blowing the dust out from around the field poles, etc., with a bellows, and last of all, wiping off the commutator with a canvas pad made as follows:

Cut a piece of ordinary canvas 6 inches square. Fold same so it is 2 inches wide by 6 inches long, which will form a pad with a face of one thickness, backed by two thicknesses. Next open up the pad and smear a little vaseline on the center section, which is the back side of the face of the pad, after which refold and let lie a few hours in a warm place, whereupon it is ready for use.

Sufficient vaseline will gradually soak through the canvas to give the commutator all the lubrication it needs, which is very little. The foregoing holds good in summer, and in winter, too, if the generator is located in a warm room. If, however, the machine is cold, then it will be well to moisten the face of the pad by using a few drops of a very thin oil on a piece of glass, spreading it around evenly and then wiping it off on the face of the pad, the idea being to get the oil evenly distributed on the pad.

Remember this, however, **too little lubrication is better than too much, and heavy lubricants (thick oils) must never, never, never be used on a commutator.** If one application, as above, during every six-hour run does not suffice, then it is likely that (1) brushes have too much tension, (2) machine is overloaded, (3) brushes not properly set, or (4) someone has put in the wrong kind of brush, which of course is not likely to happen if the machine be a new one just from the factory, but is quite possible if it be a second-hand machine, or one which has been in a repair shop.

Never use gasoline or benzine around a commutator; it is likely to attack and soften the shellac and insulation, and thus set up serious trouble.

CAUTION.—Where the mica insulation of the commutator is undercut, great care should be taken with regard to lubricating of the commutator. **If a soft brush is used no lubrication at all should be applied.** This last caution is necessary with undercut insulation, because the lubricating medium will have a tendency to combine with carbon dust and fill up the space between the commutator bars, thus in time possibly short circuiting the bars; also where soft brushes are used the brushes themselves, as a rule, contain sufficient paraffine to provide all necessary lubrication.

(d) See to it that sufficient oil, or combined oil and carbon dust, does not collect at any point or spot, either on the commutator or the face of any brush, to form a semi-insulation.

(e) That there are no high or low bars, and that the commutator is perfectly round.

(f) That a fragment of copper does not drag across the insulation between two adjacent bars, or that oil and carbon dust do not form such a bridge. This fault will be evidenced by a thin, sparkling ring of light around the commutator.

(g) That the brush springs do not carry sufficient current to heat them.

(h) **That the brushes fit properly in their holders, and are kept free from accumulation of dirt, dust, etc.** They should be taken out, their faces examined, and if necessary cleaned at the end of every 60 hours' run.

(i) That the brushes are neither too hard nor too soft.

(j) That the armature of horizontal type machines "floats" slightly, i. e., has from one-sixteenth to one-eighth inch end play, according to size of machine. This tends to prevent the brushes from cutting grooves in the commutator, hence is very important. Unless the machine sets perfectly level the armature will not "float," hence a **level setting is important.** (See "Installation" Page 445.) In vertical machines in which the armature is carried on thrust ball bearings, the brushes of opposite polarity overlap, so that the space between the brushes on the one side is covered by a brush on the other. This arrangement causes a very even, uniform wear.

(k) That the copper and mica insulation wear down evenly.

(l) That the generator is not overloaded, and that there are no other faults present which would tend to cause unnecessary sparking, or otherwise injure the commutator.

SPARKING.—Should the brushes of the motor or generator show excessive sparking, it may be attributed to one of the following causes:

(a) If it be a belt driven machine, the belt may be slipping; if the sparking is spasmodic or intermittent the trouble will probably be found in the belt, since belt slip causes sudden variations in speed, and this will, in itself, cause sparking, because it has the effect of producing heavy fluctuations in voltage. The remedy is to tighten the belt or use a belt dressing, and in this connection ordinary black printer's ink is as good an article as we know of to stop belt slipping. Ten cents' worth obtained at any printer's will last a month or more.

(b) In considering the following remember that if the machine is a new one and the rocker arm is set at the position marked by the manufacturer, as before explained, the rocker should under no condition be shifted, since the entire performance of the generator depends, in some cases, on the accurate positioning of the brushes.

Brushes not set correctly, that is to say, the rocker arm too far one way or the other; also the brushes may be too close together, or too far apart. In the first case the remedy is to move the rocker arm until the neutral position is found, whereupon sparking will either cease or be reduced to a negligible quantity. If this fails to remove the trouble, we would see if the brushes themselves are the correct distance from each other. In a two-pole machine they should bear on the commutator at diametrically opposite points. That is to say, the distance from brush-point to brush-point should be exactly the same when measured both ways around the commutator; in other words, distance A should equal distance B, as per upper drawing, Fig. 149.

If it be a four-pole machine, with two positive and two negative brushes (four altogether), the correct distance is one-fourth of the circumference of the commutator between the points of adjacent brushes; that is to say, distances marked X should all be equal, as per lower drawing, Fig. 149. If it be a machine with more than two positive and two negative brushes (more than four brushes all told), divide the number of commutator segments by the number of poles or field coils of the machine. The result will equal

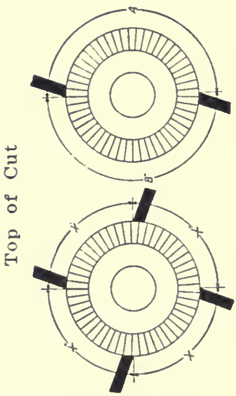


Figure 149

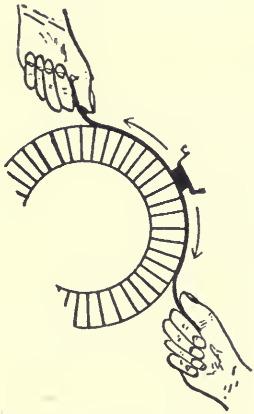


Figure 150.

the distance, in commutator bars, the brushes should be apart.

(c) Dirty brushes or dirty commutator may cause sparking, or may even prevent the generator from picking up its load at starting, and will sometimes cause a badly fluctuating arc. Some of the causes of dirty brushes and dirty commutators may be found in one of the following:

Carbon brushes contain a small amount of paraffine. When the carbon gets warm, if it be excessive in quantity, it is likely to ooze out and coat the commutator thus forming a partially insulating coating in spots, or the paraffine may mix with dust and coat the end of the brush with a semi-insulating compound. The obvious remedy is to clean the dirty parts.

To clean the commutator, use a brush stiff enough to remove any foreign matter which may cling to its surface, yet not stiff enough to injure the surface. If the brush will not remove the deposit, then use 00 sand paper **(NEVER use emery paper or emery cloth on a commutator)** applying the same while the commutator is revolving, but with just barely enough pressure to clean the metal. After having cleaned the surface, put a few drops of light oil on a cloth, or use the pad already described, holding it lightly to the commutator as it revolves. Don't get much oil on the surface of the commutator—just a "suspicion," as it were.

If it is a carbon brush which is dirty, or which does not fit the curve of the commutator, raise it just enough to slip a piece of No. ½ sandpaper between the brush and commutator, with the sand side against the brush, and pull it back and forth around the curve of the commutator until enough of the brush has been ground away to clean the surface, or to make it fit the commutator. This is illustrated in Fig. 150.

Do this very carefully. If the brush fits loosely in the hole it is best to sand in the direction of rotation only, else the brush will wiggle back and forth with the sandpaper, thus injuring rather than improving the contact. Be sure and always clean the commutator thoroughly after doing this, since if carbon dust is left adhering to its surface it may work into the insulation and cause a local short circuit between two bars.

(d) The brush not making proper contact with the commutator, which may be due to (1) tension spring not strong enough; (2) tension spring having lost its temper; (3) brush stuck in its holder; (4) brush not fitting the curve of the surface of the commutator; (5) brush holder set at the wrong angle; (6) high bar or insulation.

The remedies are: (1) Stretch the spring, if it is a spiral spring and in compression, or cut down its length if the spring be in tension. If it is not a spiral spring, do whatever is needful to make the spring stronger, installing a new one, if necessary; (2) put in a new spring and, since the fact that the old spring has lost its temper is evidence that the spring itself is carrying too much current, reinforce it with a current-carrying jumper; (3) the remedy is obvious: do whatever is needed to loosen the brush; (4) use sandpaper, as before described, until the brush fits the commutator surface; (5) straighten the holder; (6) see section f, further on.

There should, however, be only sufficient tension on the brush to insure its making good contact with the commutator. Be careful, therefore, and don't get your springs too strong. If you do there will be unnecessary wear both on the brush and the commutator, which will to some extent add the element of mechanical heat generated by undue friction.

Reasons for the brush sticking in the holder are: (1) Dirt in the holder or on the brush; (2) brush not true; (3) hammer that rests on the brush (where that type of tension is used) not working true on the slot-end of the brush. The brush should slip freely in its holder, though not freely enough to allow of any considerable amount of play, and the hammer should be so adjusted that it lies true in the slot at the end of the brush. A brush which is not true may be evened up by tacking No. 1 sandpaper on a perfectly flat surface and rubbing the brush thereon.

(e) Commutator worn too thin. If the commutator wears down too much, although it may wear evenly and appear to be in good condition, the brushes will spark in spite of everything you may do, particularly when the machine is working at capacity. The reason may lie in the fact that since the segments are wedge shape, as they wear down they become narrower, thus allowing the brush to span more of the circumference of the commutator than was intended, or there may be a slight error in the setting of the brush holder, and this error becomes greater as the distance between the brush holder and the commutator increases. The only remedy is a new commutator, but the sparking may possibly be lessened somewhat by moving the brush holder closer to the commutator. This trouble appears at its worst in a series type machine.

(f) A high or low commutator segment. This fault may usually be detected by the clicking sound made by the brush in passing over the defective segment when the machine is run at moderate speed. When the segment is low the brush rides in toward the shaft each time the bad bar passes under it. If it is high the brush will jump. The remedy will depend somewhat upon the cause. It may be that the segment has become loose, in which case it may be driven back into place by tapping lightly with a wooden mallet, or by using a wooden block and hammering gently, but the armature will probably have to be taken out and sent to the repair shop unless you yourself can tighten the clamp ring—a rather delicate operation.

If the segment is high by reason of the fact that, being of harder material than its mates, it has worn down more slowly, then, using a fine file, it may by very careful work be dressed down. If, on the other hand, it is low, then the only remedy is to turn down the rest of the bars to match.

If the fault is slight, this may be done by removing the brushes and holding a piece of grindstone which has been turned out to fit the circumference of the commutator to it while it is revolved rapidly. This process is, however, slow. The best way is to put the armature in a lathe and turn it off. In the case of a motor the grinding may, however, be done with the brushes down and the machine running by its own power, but if this be attempted it must be done with great caution.

When you are through, the face of the brushes should be thoroughly cleaned by drawing No. ½ sandpaper drawn around the curve of the commutator with the sand side next to the brushes as per Fig. 150, in order to grind off their face and thus remove any particles of sand which may have become imbedded in the brush, since such particles would scratch the commutator and cause undue wear. It is better to do the grinding with the brushes raised and the machine run from some outside source of power, if it is practicable.

(g) A rough or eccentric commutator. This may be caused by improper care, or by the use of defective materials in its construction. A rough commutator may be detected merely by feeling. The mica insulation between the segments will either stand out in ridges or be worn down so that there is a small groove between the segments. An eccentric commutator may most readily be detected by holding some instrument firmly against the frame opposite the commutator so that its end just touches the bars.

If the commutator is true it will touch all the way round as the armature is slowly revolved, but if the commutator is eccentric it will, of course, only touch the high spots. If the eccentricity be bad it will cause the brushes to move in and out of their holders perceptibly when the armature is revolved slowly. The only remedy is to turn the commutator down, and this can only be successfully done in a machine shop where work of this character is understood.

In preparing to turn down a commutator the machinist should note whether the journal or bearing points run true when the armature is revolved on its centers in the lathe. Often the centers themselves are not true with the journals, due to a defective center or a sprung shaft. In either case if the shaft be swung on its centers in the lathe the commutator will show eccentric. A competent machinist will, of course, know what precautions to take in a case of this kind.

(h) Brushes having too high resistance, the evidence of which is that they get very hot and slowly crumble away at the end next the commutator. The remedy is to get good brushes.

(i) Low bearings. In some types of machines low bearings will throw armature out of center sufficiently to distort the magnetic field, which will cause sparking. The evidence of this fault is that the air gap between the armature and the pole piece is smaller at the bottom than at the top. The only remedy is to replace the worn bearings with new ones.

(j) Short-circuited armature coil. This trouble may cause the voltmeter to fluctuate badly and the shorted coil to heat very quickly. The coil may be shorted within itself, or there may be a connection between two adjoining commutator segments. Remedy: Locate and remove the short.

(k) A reversed armature coil. This may be located by holding a compass over each coil of the armature in turn, and sending a few amperes of direct current through the coil, with the brushes raised and resistance in series to limit current flow, or current from a battery may be used. The coil which causes the compass to turn in the opposite direction from its mates is the guilty party. The remedy is, reverse the connection or direction of the windings of the defective coil.

(l) A bent armature shaft. This of, course, will cause the whole armature to wobble. The only practical remedy is a new shaft.

(m) Overload. The most prominent symptom of overload is the armature heating all over. Sparking may be lessened but not entirely stopped by moving the brushes ahead or back. By "ahead" we mean in the direction in which the armature is revolving. The remedy is obvious. Get a machine of larger capacity, or reduce the load on the one you have.

(n) High speed sparking is caused by the brushes not being able to make proper connection with the commutator by reason of excessive armature speed.

(o) A weak field. This may be detected in a generator by the inability to pick up readily, and by failure to maintain normal voltage. In a motor the starting power is decreased, but the speed and current are increased. A weak field may be caused by (1) a loose joint in the magnetic circuit; (2) heat may lower the insulation of the field winding sufficiently to allow the current to short circuit through it; (3) there may be a metallic short in the field coil. Remedies: With a voltmeter test across each field coil; the one showing the least drop is the defective one. If all read the same, then there is a loose joint in the magnetic circuit.

(p) A shaky foundation, or anything else that causes vibration in the machine, may and probably will set up the commutator sparking. The only remedy is to eliminate the vibration.

Should a ring of fire develop, or something that looks like a ring of fire around the commutator, it may be caused by (a) a piece of copper pulled across the insulation between two bars; (b) an open circuit in the armature.

In the first instance the ring will not be strong, but just a thin sparkling streak of light around the commutator. The remedy is to remove whatever is causing the short between the bars, which can usually be done by holding a piece of fine sandpaper lightly to the commutator, though the right way is to stop the machine and hunt up the trouble, using a magnifying glass, if necessary.

An open circuit in the armature might be caused by a break in one of the armature wires itself, or in one of its connections with the commutator, and these in turn may be caused by excessive current burning off one of the wires; or a nick in one of the wires may be the seat of the trouble, or the commutator may become loosened and break off one or more of the leads. The defect may be readily located, as the mica will be eaten away from between the commutator segments to which the faulty coil is connected, and the segments themselves will become full of holes and burned at the edges.

If this trouble is caught in time, the "open" may be closed and the commutator turned up true. Sometimes, by reason of carelessness, abuse or overload, the armature becomes hot, which causes the solder on the connections between the coils and commutator bars to soften, whereupon centrifugal force will throw it out, and there will, of course, be trouble, though there may be no complete opening of circuits. The action, however, so far as the ring of fire be concerned, is the same as if there were, and the commutator bars will become blackened and pitted and their edges burned. But if any of the foregoing faults be caught in time they can be remedied; if not, it will be necessary to install a new commutator, and perhaps a new armature coil or coils as well.

GENERAL INSTRUCTION NO. 8. — Before starting the machine see that it is perfectly clean and that the brushes move freely in their holders and make good contact with the commutator. Also make sure that all connections are tight.

GENERAL INSTRUCTION NO. 9.—Bearings run hot. The first rule when a bearing runs hot is to see that the oil well is filled with good clean oil and that the oil-rings run freely, carrying the oil to the shaft. If a bearing runs hot on a new machine, shut down and wash it out with kerosene. The trouble is probably due to dirt that has accumulated in shipment. If the bearing has been running along satisfactorily and suddenly gets hot, flood the well with clean oil, leaving the drain cock open and pouring in the clean oil while the machine is running, to free the bearing from dirt. A change to a different grade of oil, either heavier or lighter, will often correct a bearing trouble of this kind. Never use water to cool a bearing. It may get into the insulation of the windings and cause worse trouble A machine with clean oil of the proper grade never gives trouble from hot bearings.

GENERAL INSTRUCTION NO. 10.—Heating. Many projectionists, who handle motor generator sets and are not posted as to the permissible operating temperatures of same, become alarmed when some part or parts of the apparatus feel very hot to the touch.

The fact that a motor or generator, or parts thereof, feel quite hot to the touch does not necessarily indicate an unsafe condition.

To determine the actual state of affairs, proceed as follows: The projection room should be equipped with a good thermometer with a centigrade scale, though a Fahrenheit scale can be made to serve, provided it will register not less than 200 degrees.

The American Institute of Electrical Engineers advises, in its standardized rules, a permissible maximum actual temperature of 90 degrees C, which is equal to 194 degrees Fahr., as the limit of safe operating temperature for motor or generator parts, or for transformer coils, et cetera. This means that inasmuch as the ordinary temperature of the human body is about 98 degrees Fahr. (blood temperature) 194 degrees Fahr. would be very hot to the touch.

The right way to measure the temperature of a part is to bed the thermometer bulb in a ball of rather stiff putty, and then place the putty against the suspected part, leaving it a sufficient time for the putty to get as hot as the part is. This will cause the thermometer to accurately register the temperature of the part.

Roughly, as applies to projection rooms, we may say that any part that is not more than 50 degrees C. (90 degrees Fahr.) higher than the actual temperature of the room, is not exceeding the above named limt, and unless this limit be exceeded, the equipment will not be damaged.

NOTE.—To reduce Centigrade to Fahrenheit (C. to Fahr.) multiply the degrees Centigrade by 1.8 and then add 32. For instance, assuming a temperature of 40 degrees C., how much is it Fahr.? 40x1.8=72 and 72+32=104 degrees.

THE HERTNER TRANSVERTER.—The transverter needs no introduction. It is giving service in projection rooms all over this and other lands. It is of the "upright" type, in that its armature stands vertical, with the D. C. element at its upper end.

The generator is of the shunt wound commutating pole constant current type, the double arc machine being designed to maintain practically constant amperage under a variation of from 50 to 130 in voltage. In practice this means that the generator voltage rises from its normal of between 50 and 60 volts when one arc is operating, to from 100 to 130 volts when two arcs are burning, without causing any change in amperage. This is accomplished without the use of any resistance in series with the arc, the maintenance of constant amperage under variation in voltage being entirely automatic.

The motor is mounted in the same frame with, and immediately beneath, the generator. The motor and generator armatures are mounted on separate shafts, which same are coupled together in the following way: One half a flange coupling is fitted to the upper end of the motor armature shaft, and the other half to the lower end of the generator armature shaft. The hub of the fan which supplies ventilation is placed between the two halves of the coupling, and the whole is clamped together by bolts, so that the assembled unit, as a whole, comprises the generator armature (at the top), the fan between and the motor armature below, the power from the motor being transmitted to the generator armature by means of the coupling, which latter is so made that it can be readily disassembled, thus providing for the easy removal of the generator armature, should it become necessary in order to turn up the commutator or make other repairs.

BEARINGS.—In the base of the machine is both a radial and a thrust ball bearing, Fig. 151, the latter carrying the weight of the combined armatures and fan. The center frame section carries a radial bearing, Fig. 151, and there is a radial bearing at the upper end of the generator armature shaft, Fig. 151, so that the armature is very well supported. The bearings are all ball bearings, and they are all arranged for grease lubrication.

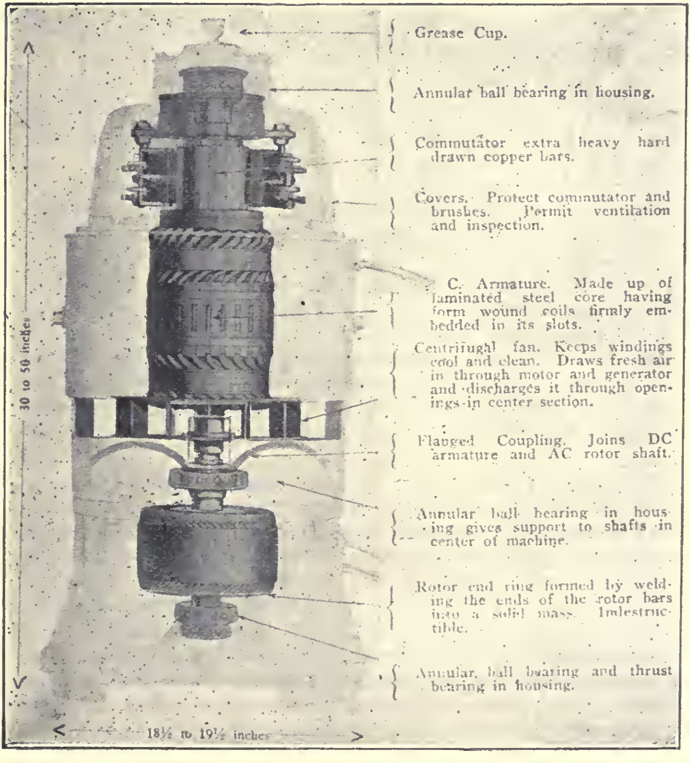


Figure 151.

CAUTION.—Grease for lubrication should be very carefully selected. It must be not only entirely free from graphite and acid, but also free from any elements which would in time form acid, because acid destroys the surface of the steel balls and the runways, causes pitting and works havoc. For these reasons we emphatically recommend that grease for use with the Transverter be purchased from its manufacturer, the Hertner Electric Company, Cleveland, Ohio.

The parts are shown in the phantom view, Fig. 151, which also gives the over-all dimensions. It will be observed that the diameter varies very little, only the height altering in machines of different capacities.

The Transverter is supplied with either one of two types of panel, termed "Panel A" and "Panel B." These consist of an inclosed steel cabinet on which is mounted a field rheostat for the generator, by means of which the projectionist may vary the current from somewhat above to somewhat below normal. The panel also carries a voltmeter and ammeter for the arc circuit. The only difference in the two panels is that panel B carries two quick-break switches to be used in making change-over. It is for the two-arc machine.

The manufacturer's claim is that the Transverter should require no attention beyond keeping it reasonably clean, putting grease into the bearings as required, and renewing the brushes when necessary. This may be quite true, in a general way, but we would nevertheless advise the projectionist to examine the machine carefully, at set intervals, because that machine never was and probably never will be made which will not require more or less expert attention.

DON'T ROCK BRUSHES.—The rocker arm should never be moved, because the performance of the Transverter depends very greatly upon the correct setting of its brushes. This adjustment is very carefully and accurately made at the factory, and the correct position of the rocker arm is marked. **If after putting in new brushes the characteristics of the machine seem to be altered, it indicates merely that the brushes are not making proper contact with the commutator.** The fault will correct itself in time, or it may be immediately corrected by inserting a piece of No. 1 sandpaper between the brushes and commutator, one brush at a time, **sand side next the brush,** and with the full tension on the brush, drawing the sandpaper back and forth around the commutator until the brush face is ground to fit the curve of the commutator surface. See Fig. 150, Page 454. If brushes are loose in their holder, draw sandpaper in direction of rotation only, since if you draw it both ways the brush will wiggle back and forth and will not fit the commutator.

Transverters are made for all commercial frequencies of current, for all commercial voltages, for single and two or three phase, and with an output capacity of from 35 to 125 amperes.

DOUBLE ARC INSTALLATION INSTRUCTIONS.—Transverters should be set on a floor which is entirely free from vibration. It is not necessary to bolt them down. Set the machine on the four cork pads which come with it. Its weight will hold it in place.

WIRING.—Make connection from the A. C. line service to the starting switch, and from the starting switch to the motor terminals, as shown in Fig. 152. Having done this, close starting switch and **make sure the armature rotates in the direction indicated by arrow on top cap of machine.** If, in the case of two or three-phase supply, the armature rotates in the wrong direction, it must be reversed by reversing one of the phases of the motor.

CAUTION.—Do not attempt to change direction of rotation or polarity by changing connections inside the machine. The machines are all checked up complete, together with their equipment, when tested. The motor must be connected to proper side of the line, and connections to panels must be made correctly in order to bring polarity of instruments and lamp right.

FUSES.—Fuse the A. C., or motor side of these machines only. The D. C. side does not require fuses or switches, other than those shown in wiring diagram. The fuses at motor starting switch must be large enough to carry the maximum load of the machine. Manufacturer's instructions, which accompany each transverter, will give the proper size of fuses for each machine.

WIRING TO LAMPS.—Use wire of sufficient size to carry the rated D. C. amperage from point L on Transverter to point A on panel board, Fig. 152. No. 12 or No. 14 wire may be used to connect point F on Transverter to point F on panel board, Fig. 152.

OPERATING INSTRUCTIONS.—Before starting motor, have lamp carbons separated and projector table switches open Close motor starting switch. Close short circuiting switch which controls lamp you do NOT wish to use. Allow sufficient time for generator voltage to build up before attempting to strike an arc, say 15 seconds from time of starting motor, then bring carbons together, **instantly** slightly separating them again. As the carbons heat up, gradually separate them until the proper arc length is had, whereupon

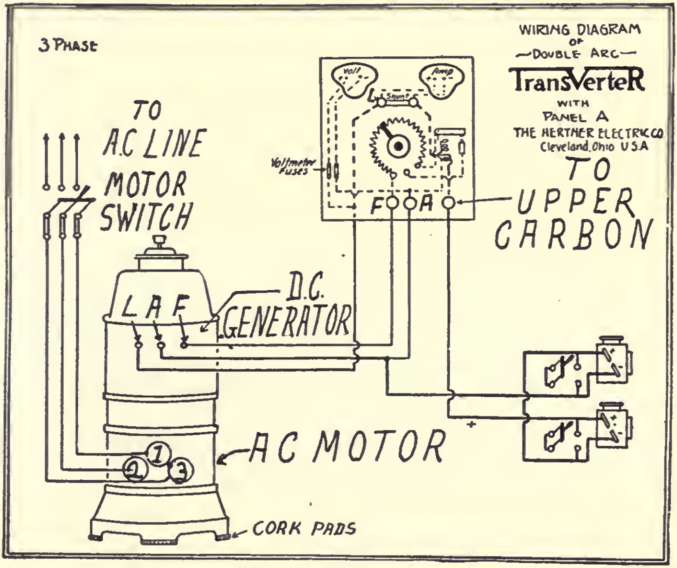


Figure 152.

the voltmeter will show 55 volts, provided the carbons be of correct size and correctly set. Any desired change in amperage, within the range of the machine, may be made by changing the position of the field rheostat regulator, but it must be remembered that the regulator provides means for obtaining amperage in excess of the rated capacity of the machine, **which excess should not be used continuously.** It is intended only to provide excess current for use where a temporary excess of light is desired by reason of a very dense film, or by reason of heavy tinting. The regulator also provides means for obtaining a less amperage than the rated capacity of the machine. If the projectionist will take advantage of this provision he will not only improve his work, but will also effect a considerable saving in light bills.

TO STRIKE A SECOND ARC.—Assuming one projector to be already in operation, adjust its arc to a 55-volt length, then bring the carbons of the idle lamp into contact, and, still holding carbons of idle lamp in contact, open panel board short circuiting switch controlling that lamp. When switch is open, instantly, but slowly separate carbons, in the manner already directed for a single arc. When both lamps are in use the voltmeter on panel board will indicate the combined voltage of both arcs, which should read between 105 and 120 volts, probably about 110.

To "kill" either arc it is only necessary to close the panel board switch controlling that lamp. This in no way affects the remaining arc.

GENERAL CARE.—Keep the machine clean. **Do not use sand or emery paper on commutator.** Should the commutator become dirty, hold a piece of coarse canvas or cheese cloth firmly against its surface while machine is running, and when free of dirt, wipe the surface with a clean cloth pad, moistened very **SLIGHTLY** with pure vaseline. See Section C general instructions No. 7.

Do not permit the brushes to become too short. If you do, disastrous sparking will result. A new set of brushes should be put in before the old ones are entirely worn out. **Instead of putting in a new set all at one time, it is better to put in two first, one in each holder, and at opposite ends of commutator. Run that way until the new brushes have worn to a perfect fit, whereupon you may replace the other worn brushes with new ones.**

NOTE.—An extra set of brushes are shipped with every Transverter, and **no other grade of brush should ever be used.**

The three grease cups on the machine should be given one-half turn once every two (2) weeks. If this is done these cups will require refilling every thirty or forty days.

When ordering parts from manufacturer always give number on name plate of the machine.

D. C. TO D. C. TRANSVERTER.—When the theatre is supplied with direct current at a pressure of 250 volts or more, the Hertner Company makes a motor generator set consisting of the standard Transverter generator direct connected to a D. C. motor. This particular type of machine is made horizontal, instead of vertical. The units are mounted on ball bearings, and are provided with centrifugal fans.

Where the theatre is supplied with direct current at a pressure of from 110 to 250 volts, a special transverter has been designed, for which the manufacturers claim an efficiency of about 80 per cent. when the machine is operating on a 220-volt supply, and somewhat higher efficiency when the supply is at 110 volts. This machine might be called a D. C. auto transformer. It consists of a D. C. armature with a single commutator, which is provided with a third set of brushes. By a peculiar arrangement or winding of the fields, a constant current may be taken off the commutator when constant voltage is supplied.

This machine is vertical in design, and its moving elements are carried by ball bearings. It is equipped with the usual centrifugal fan.

Figure 152½.
D. C. to D. C. Transverter

The installation of these D. C. to D. C. machines is in general the same as the A. C. to A. C. equipments, with the substitution of a D. C. motor starter for the A. C. switch or starter, and its care is fully covered under the instruction for the A. C. transverter.

GENERAL ELECTRIC COMPENSARCS.—The General Electric Company applies the name compensarc to three different types of machine, viz.:

The A. C. to D. C. Motor Generator Compensarc.
The D. C. to D. C. Motor Generator Compensarc.
The A. C. to A. C. Projection Transformer Compensarc.

The General Electric Motor Generator Compensarc, both A. C. to D. C. and D. C. to D. C., are horizontal type machines, designed for the operation of two projection arcs without resistance in series therewith. The arcs may be operated either singly or in series, amperage remaining constant, no matter whether one or two arcs are burning. The voltage of the generator, however, doubles when the second arc is struck. No resistance is used in series with the arc, either when burning singly or when both are in use.

The A. C. to D. C. type consists of an A. C. motor and a D. C. generator mounted upon a cast-iron sub-base, their armature shafts connected by means of a rigid coupling.

The general appearance of the A. C. to D. C. set is shown in Fig. 153, in which the smaller element is the A. C. motor. The motors are standard A. C. machines, but the generators are wound specially for projection work. These sets are built

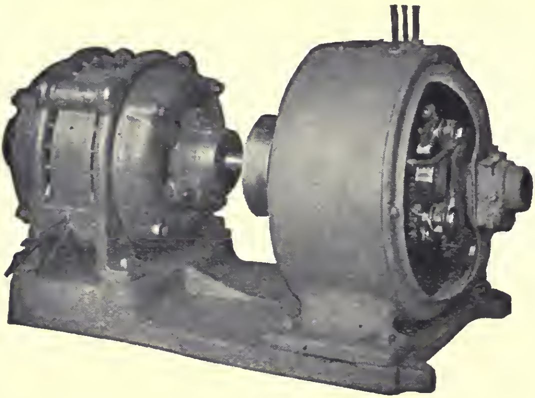


Figure 153.

in five standard sizes, delivering 35, 50, 70, 100 and 125 amperes D. C. to the arc. The A. C. motor may be had for any standard voltage or current frequency, and for single two or three-phase current. The machines are well made and have been in use for quite a long while, giving excellent results and general satisfaction.

The appearance of the D.C. to D.C. is shown in Fig. 154. It consists of a D.C. motor and a D.C. generator, the armature shafts of which are rigidly coupled. They are intended primarily for use on high voltage D.C. current supply, the term high voltage being intended to indicate anything from 220 volts up. These sets and the A.C. to D.C. sets are made in the same standard sizes. If designed to operate from 110-volt supply the matter of electrical efficiency of the machine should have very careful consideration, but for 220 volts or higher there can be no question as to their being an excellent investment.

Each two-lamp series type motor generator compensarc consists of a completely assembled motor and generator and a steel cabinet panel for the generator, in which a field rheostat is mounted.

We get an idea of the appearance of this panel in Fig. 155. On its face is an ammeter, calibrated only for the operating range of the set. The black mark approximately in the center of the scale shows the normal point at which the set should be operated. Other marks indicate both the high and the low operating points. Beyond these two latter marks there is no calibration as they represent the extreme range of capacity of the machine.

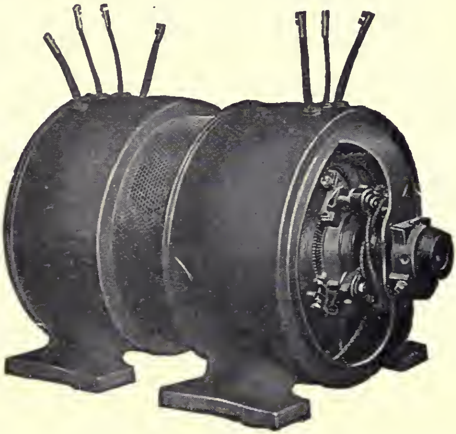


Figure 154.

The panel is so arranged that the front, carrying the rheostat and ammeter, may be removed, the cabinet be put in place, all conduit and wiring arranged and then the steel front carrying the ammeter and rheostat, put into place and connected. This is an excellent plan, in that it protects the instruments from any possible damage during installation. A door on the side of the cabinet gives access to connections for inspection and for test after installation.

The set includes two S.P.S.T. enclosed knife switches. These are the short circuiting switches. They are all ready for mounting on the projector, along with the main projector table switch and motor drive switch. Closing either of these switches has the effect of short circuiting the lamp it controls.

so that no current will pass through the lamp. They should be connected ahead of the projector table switch. If this is done the idle lamp may be trimmed without opening the circuit.

The following are the dimensions data of the steel panel:

RATING OF COMPENSARC	AMMETER SCALE MARKING	DIMENSIONS IN INCHES		
		Height	Width	Depth
Two 35-amp. lamps	0- 30- 35- 40	11	8½	4¾
Two 50-amp. lamps	0- 40- 50- 60	11	8½	4¾
Two 70-amp. lamps	0- 60- 70- 80	11	8½	4¾
Two 100-amp. lamps	0- 90-100-110	17	12½	6¾
Two 125-amp. lamps	0-110-125-135	17	12½	6¾

When one arc is burning the process of starting the other is as follows: Close the projector table switch and freeze the carbons of the idle lamp. Next open the short circuiting switch of the idle lamp and separate the carbons in the usual way, except that it should be done very slowly. As the second arc is sprung, the machine automatically increases its voltage until it has double the voltage required to force the current against the resistance of one arc; in other words, until it is sufficient to force the current against the resistance of the the two arcs operating in series. Ordinarily this will be between 105 and 120 volts, varying with the amperage. See Page 400.

To strike either arc alone it is only necessary to open the short circuiting switch of the lamp you are going to use, close the other short circuiting switch and strike the other arc in the usual way. Under this condition the dynamo will automatically generate only that voltage necessary to force the current across the resistance of the single arc.

To extinguish either arc when both are burning, slowly feed the carbons of the lamp together until they are in contact, whereupon close the short circuiting switch of the lamp it is desired to extinguish. An arc may, of course, be extinguished merely by closing its short circuiting switch, but this would give the machine no chance to gradually decrease its voltage to meet the new condition. The bringing of the carbons of the lamp into contact with each other slowly, operates to lower the voltage of the generator gradually, so that there is no shock to it when the short circuiting switch is closed.

For directions as to the installation and care of the compensarc see general instructions, in addition to which full directions and wiring diagrams will accompany each set.

The following data is supplied by the manufacturer. It will be found useful to those contemplating the purchase of a set. We do not vouch for the electrical data, though we have no reason to question its correctness.

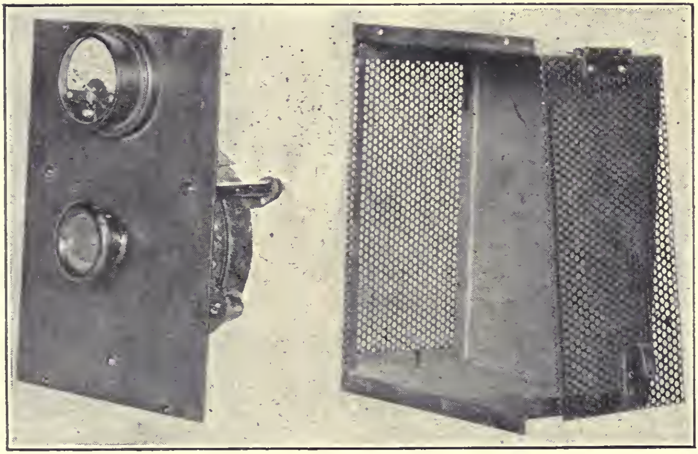


Figure 155.

Steel Panel with Type AM Ammeter for Motor Generator Compensarc. Front Removed Showing Box Construction.

WESTINGHOUSE MOTOR GENERATOR EQUIPMENT. —Westinghouse motor generator equipment for motion picture theatres consists of a motor generator, with a single or polyphase A.C. motor, or a D.C. motor, generator, field rheostat, ballast rheostat, motor starter, and control panel. The motor generator is designed especially for this service, and is of sufficient capacity to deliver 100 per cent. overload during the time one arc is projecting the picture and the carbons of the second lamp are warming up. The generators are compound wound for 75 volts at full load, and are designed to give approximately the same voltage at 100 per cent. overload during the time

MOTOR-GENERATOR COMPENSARCS

For Motion Picture Projection
1800 R.P.M.

A-C. to D-C.

***60 CYCLES**
Voltage (See Table)

Conversion	†Line Voltage	No. of Phases	Ship. Wt. in Lb. (Apprx.)	Electrical Data: Effi. in Per Cent	Electrical Data: P-F. in Per Cent	Dimensions in Inches (Approx.) (See Fig. 2): AA	BA	BU	C	E-5	E-6	JN	OL	RP	U	V	Y	Z	Motor: Type	Frame	H.P.
35-AMP. OUTFIT—For Two 35-amp. Arc Lamps Alternately																					
A-C. to D-C.	110 220	1 1	1100	63	98	44 19/32	12¾	......	18⅝	6½	6¼	19¼	13½	21⅞	32 3/16	20½	17¼	⅝	RI	592	5
	110 220 110 220	2 2 3 3	900	70	81	37⅞	12½	8½	18½	5⅞	6¼	19¼	13¾	21⅞	30 1/16	20½	17¼	⅝	KQ KT	731	5
50-AMP. OUTFIT—For Two 50-amp. Arc Lamps Alternately																					
A-C. to D-C.	110 220	1 1	1200	66	97	46 27/32	14⅛	......	19 5/16	7	6¼	19¼	14¾	21⅞	33¼	20½	17¼	⅝	RI	610	7.5
	110 220 110 220	2 2 3 3	1150	71	84	39¾	15¾	10 1/16	20⅛	6⅝	6¼	19¼	16	21⅞	32	20½	17¼	⅝	KQ KT	750	7.5
70-AMP. OUTFIT—For Two 70-amp. Arc Lamps Alternately																					
A-C. to D-C.	110 220	1 1	1600	68	97	52 15/16	16¾	......	21¾	6¾	7⅜	21⅞	18½	25 5/16	37	22⅜	19	⅝	RI	627	10
	110 220 110 220	2 2 3 3	1500	72.5	84	46	15¾	11⅝	21¼	7¼	7⅜	21⅞	16¼	24 5/16	36⅝	22⅜	19	⅝	KQ KT	751	10
100-AMP. OUTFIT—For Two 100-amp. Arc Lamps Alternately																					
A-C. to D-C.	220 220	2 3	1700	74	88	50⅞	15¾	11⅝	22¼	7 13/16	7⅜	21⅞	16¼	25 5/16	40½	22⅜	19	⅝	KQ KT	752	15
125-AMP. OUTFIT—For Two 125-amp. Arc Lamps																					
A-C. to D-C.	220 220	2 3	1800	75	86	52	15¾	11⅝	22¼	7 13/16	7⅜	21⅞	16¼	25 5/16	41 1/16	22⅜	19	⅝	KQ KT	753	20

* These sets can be built for operation on 25, 40 and 50 cycles. Prices will be furnished on application. † Can be furnished for voltages up to and including 550 without increase in price. For other voltages, price will be furnished on application.

the second arc is warming up. These equipments are built in various sizes suitable to meet the requirements of any theatre from the smallest to the largest.

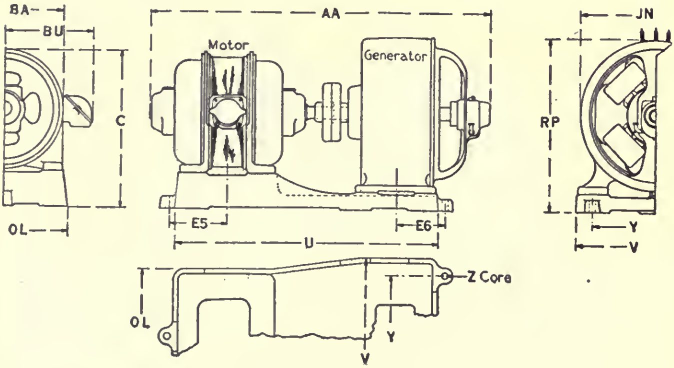


Figure 156.

BALLAST RHEOSTATS.—Ballast rheostats are an essential part of the equipment, one being connected in series with each arc, as shown in Fig. 163. They serve as ballast to any fluctuations in current caused by variations in the resistance of the arc circuit. The rheostat consists principally of one frame of grids, a face plate with handle for varying the resis-

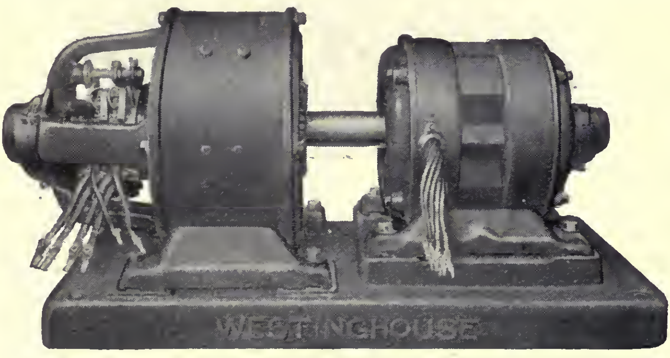


Figure 157.
Motor Generator With Polyphase A. C. Motor

tance, two metal plates, one on each side, and wire mesh work guard over the top, back and bottom. The construction provides for ample ventilation, and the enclosing feature allows their use in the projection room without fire risk.

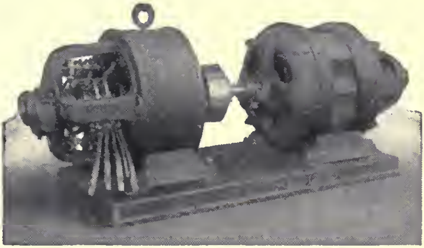


Figure 158.
Motor Generator With Single Phase A. C. Motor

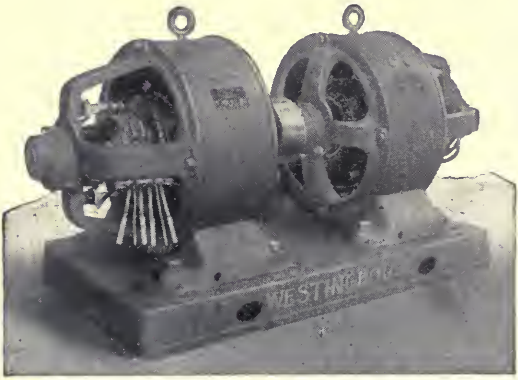


Figure 159.
Westinghouse Motor Generator With A. C. Motor

THE CONTROL PANEL.—The control panel illustrated in Fig. 160 is made of black slate, 1x16x18 inches. The edges are beveled to add to appearance, and it is arranged for wall mounting on strap iron supports. The two sides, top and bottom, are enclosed by wire mesh, and the back by a steel plate. The panel is furnished complete with ammeter and shunt with 40-foot leads, voltmeter, and a mounting for the generator field rheostat. The instruments have black faced dials and white pointers.

The starters for the induction motors are either quick-make and break switches, Fig. 161, or type A auto starters, Fig. 162. Starting rheostats are furnished with the D. C.-D. C. motor generators.

These equipments are designed to supply current for two arcs operating in independent parallel circuits, with a stabilizing adjustable ballast rheostat in each circuit. This arrangement has a decided advantage in that each arc operates entirely independent of the other; hence, if one arc should "break" while being adjusted for the next reel, the other arc

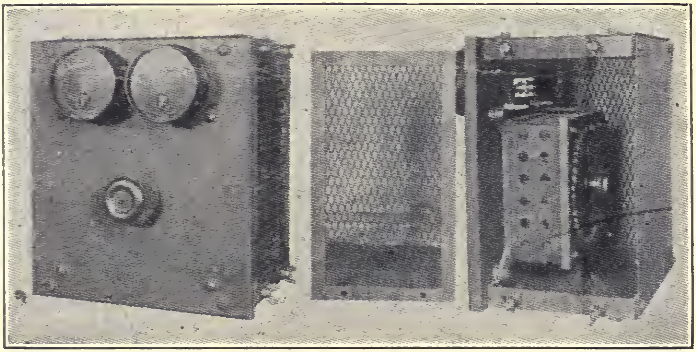


Figure 160.
Control Panel. Front and Side Views.

will be in no way affected. Furthermore, any fluctuations of current in one arc circuit are not accompanied by corresponding fluctuations of current in the other arc circuit. This arrangement also provides for simultaneously operating arcs of different current strength; for instance, an arc for a stereopticon requiring 25 amperes, and an arc for a spot light requiring 50 amperes.

HEATING.—See General Instruction No. 10.

INSTALLATION UNPACKING.—(See General Instruction No. 1). When uncrating the equipment, protect the various units against severe shocks and blows, especially if the temperature of the air be very low. **Do not remove the blocking between the generator and motor frames until the set is finally installed at its permanent location. Furthermore, these**

sets should never be moved from their permanent location unless suitable blocking is placed between frames of the motor and generator. This is necessary in order to prevent danger of bending the bearings out of alignment. Be sure to protect all the equipment from moisture (see General Instruction No. 1) and **to make sure all windings of the motor and generator are dry before subjecting them to operating voltage.**

LOCATION.—All of the electrical equipment should be finally installed in a clean, dry, well ventilated place, and in such a manner as to be easily accessible for inspection and cleaning. The room or enclosure for the equipment should be sufficiently well ventilated so that the air temperature will never be in excess of 104 degrees Fahrenheit. See General Instruction No. 10.

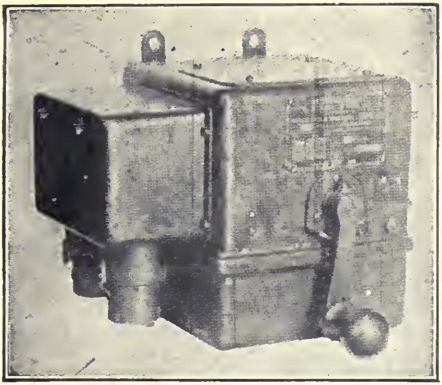


Figure 161.
Quick Make and Break Switch

FOUNDATION.—In order to make the motor generator readily accessible, it is advisable to construct a supporting foundation which will raise it up, thereby preventing the magnetic hum and vibration being transmitted to the floor and the walls of the room. It is advisable to place on its top a vibration and sound-absorbing base, details of the whole being as follows:

First, construct a sub-base of such height that when the whole thing is done the bottom of the bed plate of the machine will be about two feet above the level of the supporting floor. This supporting base is best made of cement, but may be made of brick, or even stone. It need not be solid, but only consist of an outer shell, 6 inches thick if it be of cement, or 8 inches if it be of brick. If the base is built of brick, the mortar should be a rich lime mortar, strongly tempered with cement.

Anchor bolts to hold down the top, or sound-absorbing base, should be built into the foundation, extending up far enough above the top of the sound-absorbing base so that nuts may be placed on the upper end, which should be about 8½ inches above the top of the supporting foundation. These bolts must be so placed that they will not come in contact with the iron of the base plate. They are designed only to hold the sound-absorbing base down solidly on top of the supporting foundation.

On top of the supporting foundation just described, a sound-absorbing base should be placed, consisting of two layers of solid planking, each layer two inches thick, and two layers of solid cork, each layer two inches thick. Both layers of cork should be placed on the top of the supporting foundation, with the planking on top of the cork, the boards of one layer extending one way, and the boards of the other layer the other way. In other words, the two layers of planking should be laid at right angles, and the layers of the planking must be securely bolted or nailed together.

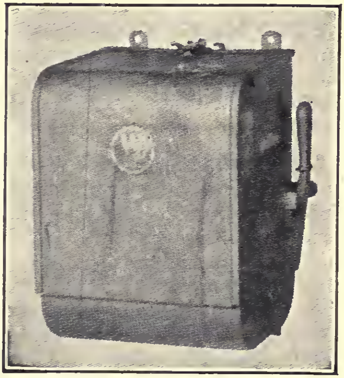


Figure 162.
Auto Starter

After the cork and planking frame is in position, the anchor bolt nuts should be drawn up tight, remembering that they must not come in contact with the metal of the machine base plate. The motor generator may then be mounted on the plank frame and, if desired, the bed-plate may be bolted down to the plank frame by means of heavy lag screws, as holes are provided in the bedplate for this purpose. If so desired, heavy felt may be substituted for the cork, but cork is much more resilient, and will remain elastic indefinitely, whereas felt will not.

When constructing the foundation and sound-absorbing base, it is essential that the top of the plank platform be

perfectly level, so that the oiling system of the motor-generator will not fail after the set is installed.

NOMENCLATURE.—Where an installation is referred to in this article as a "two-light" machine, it is meant an equipment is designed to serve on a projection installation where the projectors are to be operated alternately for "change over" or continuous picture service. Such equipment may be used to warm up the carbons of the idle projector for a period of approximately one minute while the other projector is in operation.

EQUIPMENT REQUIRED.—For each single-light installation a motor generator and one ballast rheostat is required, the control switch being optional, whereas, for each two-light installation, a motor generator, two ballast rheostats and two control switches are necesary.

INSTRUCTION FOREWORD.—For all cases wherein the instructions are equally applicable to both types of installation, namely, two-light and single-light, no distinction will be necessary. However, when the instructions apply to only one of these types, then the type which is involved will be clearly indicated.

A control switch is a single-pole, single-throw knife switch, which must be protected by a suitable cover if mounted on the frame of a motion picture projector. If the control switch is mounted on a switchboard panel, then the individual cover is not necessary.

INSTALLATION OF MOTOR GENERATOR.—Install the motor generator in the projection room or, preferably, in a room located as near as possible to it. See General Instructions No. 1.

MOTOR STARTING EQUIPMENT.—Install the motor control equipment for the motor generator as near to the motor generator as is convenient.

BALLAST RHEOSTATS.—These should be installed either in the motor generator room or in the projection room. The ballast rheostat should be placed in an upright position, so as to allow free circulation of the air, vertically, between the grids.

CONTROL SWITCHES.—The control switch for each ballast rheostat should, preferably, be mounted on the frame of the motion picture projector, with which the ballast rheostat is to be used, beside the projector table switch.

CONTROL PANEL.—This panel should preferably be mounted between the two projectors, though any other convenient place will do.

WIRING AND CONNECTING. TYPE CS POLYPHASE MOTORS.—Connect the motor and auto-starter as per diagram furnished with the auto-starter. If the circuit is 2-

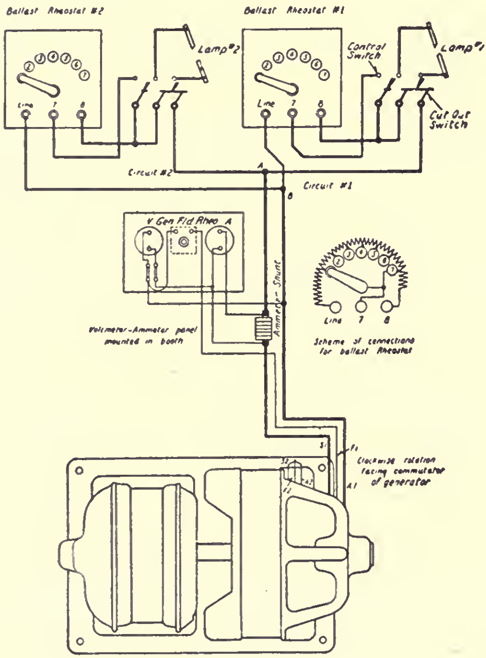


Figure 163.

Diagram of Wiring Connections for Two-Lamp Installation.
(For one-lamp installation omit connections left of points A & B)

phase, 4-wire, connect leads from one phase to motor terminals A1 and A2, and leads from other phase to terminals B1 and B2. If circuit is a 2-phase, 3-wire, connect outside leads to terminals A1 and B1, and middle lead to A2 and B2. If circuit is a 3-phase, connect any lead to any terminal. To obtain proper direction of rotation see instructions further on. If fuses are used in the supply circuit, they should carry current in excess of current indicated in nameplate as follows:

2-phase, 4-wire circuit, all leads, 25 per cent.

2-phase, 3-wire circuit, outside leads, 25 per cent., middle lead, 75 per cent.

3-phase, 3-wire circuit, all leads, 25 per cent.

If circuit-breakers are used in the supply circuit, they should be adjusted to open the circuit in accordance with the above.

Fuses in the starting circuit should carry four or five times the rated current.

LUBRICATION.—Before starting, fill the oil reservoirs with the best quality of clean dynamo oil; **overflow plugs must always be kept open.** The old oil should be withdrawn occasionally, and fresh oil substituted. The old oil may be filtered and used again. See General Instruction No. 3.

INSTRUCTIONS FOR OPERATING THE EQUIPMENT (TWO-LAMP INSTALLATION).—1. Before starting the motor-generator, see that all switches are open and that the ballast rheostat contact arms are on the right, indicated as button No. 7 in the diagram, Fig. 163.

2. Close the motor starting switch.

3. When motor generator reaches full speed, adjust the generator field rheostat until the voltmeter registers approximately 75 volts.

4. Close the cut-out switch on motion picture projector No. 1 and bring the carbons together. After the carbons have been warmed strike the arc by separating them slightly, and then close the single pole control switch, which short circuits part of the ballast resistance.

5. Adjust the carbons until the best possible operating condition is obtained. If the current is not of the correct value to give proper illumination of the screen, move the contact arm of the ballast rheostat to the left, one button at a time, until the proper illumination is obtained. The button which gives the proper illumination should be noted, so that it can be identified when projector No. 1 is again placed in operation.

6. A short time before the end of reel No. 1, close the cut-out switch on projector No. 2 in order to warm up the carbons.

7. After the carbons have been warmed, strike the arc and then close the single pole control switch, which short circuits part of the ballast resistance in ballast rheostat No. 2.

8. Adjust the carbons of No. 2 projector until the best possible operating condition is obtained. If the current is not of a value to give the proper illumination, then move the contact arm of the ballast rheostat to the left, as explained in paragraph 5, until the desired result is obtained.

9. At the proper time start projector No. 2 and immediately disconnect the circuit to No. 1 projector by opening the cut-out switch and the control (projector table) switch.

10. Before shutting down the motor generator, disconnect the direct current end by opening all the cut-out and control (projector table) switches, then open switch connecting motor to supply line.

NOTE: The electrical equipment is fully as important as the projectors, and should receive equal care and attention. Read Instruction Book No. 5164A for information in detail on the installation and operation of Westinghouse motion picture motor generator equipment. It accompanies each set, or may be had, free of cost, by addressing the Westinghouse Company, East Pittsburgh, Pa.

REVERSING MOTOR GENERATOR.—The rotating element of the motor-generator should revolve in a clockwise direction, as observed by viewing the generator end of the set. If this is not the case when the motor is started, then the wiring connections for the motor must be changed.

TO REVERSE MOTOR—TYPE CS POLYPHASE MOTOR.—To reverse a two-phase, 4-wire motor, the two leads of one phase should be interchanged. To reverse a 2-phase, 3-wire motor, the two outside leads should be interchanged. To reverse a 3-phase motor, any two leads should be interchanged.

TO REVERSE TYPE AR SINGLE-PHASE MOTOR.—The direction of rotation is determined by the position of the brushes, and is indicated by a scale on the rocker ring, and a pointer on the front bearing bracket. The scale consists of three lines marked RR, N, and RL, respectively. When the rocker ring is turned so that the pointer is opposite RR, the motor will run in a right-hand, or clockwise, direction as you face the commutator, and when the pointer is opposite RL, the rotation will be left-hand or counter-clockwise. N is the neutral point; the armature will not turn if the pointer is opposite this line. To reverse the motor, therefore, loosen the rocker ring set-screw and turn the rocker ring until the pointer is opposite the line for the reverse direction of rotation.

CARE OF MOTOR GENERATOR. TYPE SK GENERATOR AND MOTOR. COMMUTATOR.—The commutator must be kept clean, and the brushes properly adjusted and fitted to the commutator. Wipe the commutator at frequent intervals, depending on the character of the service, with a piece of clean canvas cloth free from lint. Apply lubricant sparingly; a piece of paraffin rubbed lightly across the commutator surface will furnish sufficient lubrication. No other attention is required by a commutator which is taking on a polish and shows no sign of wear. A rough, raw, copper-colored surface should be smoothed with a piece of sandpaper, or fine sandstone ground to fit. In any case the final smoothing should be done with fine (No. 00) sandpaper. When using the paper or stone, lift the brushes and do not replace them until all grit is removed. NEVER USE EMERY PAPER ON THE COMMUTATOR. See General Instruction No. 7.

BRUSHES.—The brushes are set in the neutral position at the factory, and the bracket to which they are attached is doweled in position. **This adjustment should not be altered. It is correct for either direction of rotation.**

IMPORTANT.—New brushes should be of the same make and grade as those shipped with the machine. Brushes should have only sufficient clearance in the box to slide easily.

RENEWING BRUSHES—TYPE AR SINGLE-PHASE MOTOR.—To remove brushes from the holder, turn the rocker ring so that the brushes are brought between the arms of the bearing bracket. Remove the screws of the clips that hold the brushes in place. After inserting new brushes, turn the rocker ring so that the pointer is opposite the line for the proper direction of rotation. The front bracket of the motor should not be removed if it can be avoided. **If the bracket is removed, when replacing same, make sure the steel pin in brush-raising ring enters corresponding slot in the brushholder casting. Failure to observe this may result in poor operation.**

GENERAL POINTERS—GENERATOR EXCITATION.—When a generator is started it may fail to build up its voltage properly. This may occur, even though the generator operated perfectly during the preceding run. This may be due to one or more of the following causes:

(a) Slow speed.

(b) Open shunt-field circuit, caused by faulty connections or defective field coil or field rheostat.

(c) Open armature or commutating-field circuit.

(d) Incorrect setting of brushes.

(e) Reversed series or shunt coils.

(f) Poor brush contact due to dirty commutator or brushes sticking in holders.

(g) Loss of residual magnetism.

Examine all connections; try a temporarily increased pressure on the brushes; look for a broken or burned out coil in the rheostat. An open circuit in the field winding may sometimes be traced with the aid of a magneto and bell; but this is not an infallible test, as some magnetos will not ring through a circuit of such high resistance as some field windings have, even though the winding be in good order and intact. If no open circuit is found in the rheostat, or in the field winding, the trouble is probably in the armature. But if it be found that nothing is wrong with the connections or the winding, it may be necessary to excite the field from another generator, or by some outside source. Calling the generator that we desire to excite No. 1, and the machine from which current is to be drawn No. 2, the following should be the procedure:

Open all switches and remove all brushes from generator No. 1. Connect the positive brushholder of generator No. 1 with the positive brushholder of generator No. 2; also connect the negative holders of the machines together. In making these connections it is advisable to complete the circuit through a switch protected by a fuse of about 5 amperes capacity. Having completed the connection close the switch. If the shunt winding of generator No. 1 is all right, its field will show considerable magnetism. If possible, reduce the voltage of generator No. 2 before opening the exciting circuit; then break the connections. If this cannot be done, set the field rheostat contact arm of generator No. 1 on button marked "IN," then open the switch very slowly, and gradually lengthen the arc which will be formed, until it breaks.

A very simple means for getting a compound-wound machine to pick up, is to short-circuit it through a fuse having approximately the current capacity of the generator. If sufficient current to melt this fuse is not generated it is evident that there is something wrong with the armature—either a short circuit or an open circuit. If, however, the fuse has blown, make one more attempt to get the machine to excite itself. If it does not pick up it is evident that something is wrong with the shunt winding or connections.

If a new machine refuses to build up voltage, and the connections apparently are correct, reverse the field connections, i. e., interchange the field wires which are connected to the positive and negative terminals of the generator. If this interchange of connections does no good, re-establish the original connections and locate the fault as previously advised.

BRUSHES.—See General Instruction No. 7. All brush faces resting on the commutator should be fitted to the commutator so that they make good contact over the entire area. This can be most easily accomplished after the brushholders have been adjusted and the brushes inserted. Lift one set of brushes so that they will not be forced against the commutator. Place a piece of No. ½ sandpaper against the commutator with the sanded side toward the brushes. Replace one brush in its holder and allow the spring to force it against the sandpaper. Draw the sandpaper in the direction of rotation under the brush, releasing the pressure as the paper is drawn back, being careful to keep the ends of the paper as close to the commutator surface as possible, thus avoid rounding the ends of the brush. After the first brush is properly ground, it should be lifted sufficiently to prevent its being forced against the commutator, after which the remaining brushes of the set may be similarly ground, one at a time.

By this means a satisfactory contact is quickly secured, each set of brushes being similarly treated in turn. If the brushes are copper plated, their edges should be slightly beveled, so that the copper does not come in contact with the commutator.

INSPECTION.—Make frequent inspection to see that (a) brushes are not sticking in holders; (b) pig-tail shunts are properly attached to brushes and holders; (c) tension is readjusted as the brush wears; (d) copper plating is cut back so it does not make contact with commutator; (e) wornout brushes are replaced before they reach their wearing limit and break contact with the commutator; (f) any free copper picked up by the face of the brushes is removed.

COMMUTATOR.—See General Instruction No. 7.

HEATING FIELD COILS.—Heating of field coils may result from any of the following causes: (a) too low speed;

(b) too high voltage; (c) too great forward or backward lead of brushes; (d) partial short-circuit of one coil; (e) overload.

HEATING OF ARMATURE.—Heating of armature may result from any of the following causes: (a) too great a load; (b) a partial short-circuit of two coils, heating the two particular coils affected; (c) short-circuits or grounds in armature winding or commutator; (d) bad commutator, with consequent large circulating current in armature coils undergoing commutation.

HEATING OF COMMUTATOR.—Heating of commutator may result from any of the following causes: (a) overload; (b) sparking; (c) too high pressure.

BUCKING.—"Bucking" is the very expresive term descriptive of the arcing between adjacent brush arms. In general, bucking is caused by excessive voltage between commutator bars, or by abnormally low surface resistance on the commutator between brushholders of opposite polarity. Any condition tending to produce poor commutation, increases the danger of bucking. Among other causes are the following: (a) rough or dirty commutator; (b) a drop of water on the commutator from the roof, leaky steam pipes or other source; (c) short-circuits on the line producing excessive overloads.

HALLBERG D. C. TO D. C. MOTOR GENERATOR.—The Hallberg D. C. to D. C. motor generator consists of a D. C. motor, directly connected to a specially wound generator which delivers current to the arc at arc voltage, so that there is no necessity for resistance in series with the arc. The only waste is the power consumed in the machine itself. The saving accompanied by its installation will therefore be the difference between its efficiency and the efficiency of rheostatic resistance, plus the interest on the sum the motor generator costs over and above the cost of a rheostat or rheostats.

The manufacturer gives the following data. We cannot vouch for the efficiency claims, which, even though we concede their entire correctness, can only be maintained if the machine be kept in first-class condition.

LINE INPUT.

Line fuses required.	Line volts.	Amperes.	Line watts.
20 Amp.	110	17	1,870
10 Amp.	220	10	2,200
5 Amp.	550	4	2,200

OUTPUT AT ARC.

Arc voltage.	Arc amperes.	Arc watts.	Watts loss.	Efficiency.
50-55	30	1,650	220	88%
50-55	30-35	1,650	550	75%
50-55	30-35	1,650	550	75%

In considering a matter of this kind it should be remembered that when opposed to 110 volts a rheostat is less than 50 per cent. efficient. In other words even where the supply voltage is only 110 there is more power consumed in the rheostat than is used in the arc itself. If the supply voltage

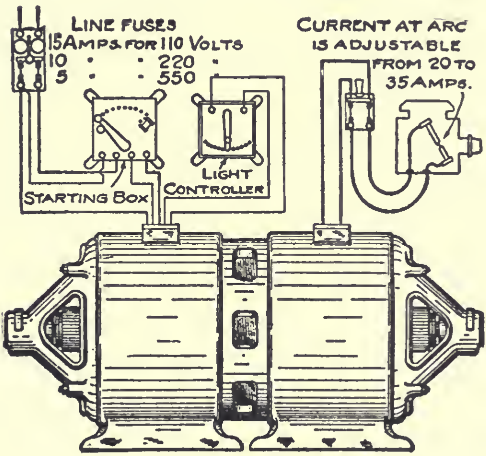


Figure 164.

be 220, then the power consumed in the rheostat is about three times the power consumed in the arc.

Fig. 164 shows the general make-up of the 110 volt type of D. C. to D. C. motor generator. While constructed along the lines of a motor generator, this machine is, in the strict sense of the word, only in part a motor generator. The principle involved permits the use of a smaller and more efficient motor and generator than would be possible were the apparatus a straight motor generator set.

The 110 volt outfit is provided with an automatic starting box and light controller by means of which the projectionist may vary the arc amperage anywhere between 20 to 30 on the 25 ampere size; from 30 to 40 on the 35 ampere size; and from 40 to 60 on the 50 ampere size. By the use of a special controller (furnished upon request) it is possible to cause all D. C. to D. C. sets to deliver less than their rated minimum amperage, although we believe that if this is done there will be some sacrifice in efficiency.

Fig. 165 shows the Hallberg D. C. to D. C. straight motor generator set, made for supply voltage ranging from 200 to 750, in which the generator is designed and wound to deliver a constant amperage to the arc, without the use of resistance in series therewith. These sets are supplied with a complete automatic starter and light controller; also they have a pulley coupling between the motor and generator, on which it is possible to place a belt for driving the motor generator by means of an engine. Under this condition the generator end will supply a projection arc, and if desired the motor end can be made to supply a limited number of lights or fan motors. This latter is a feature which might, under some conditions, be of considerable value to the exhibitor.

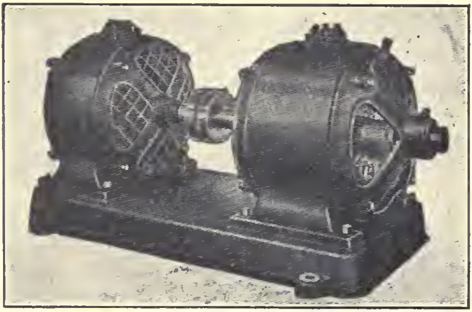


Figure 165.

Another advantage in connection with this set is that its low voltage side is an entirely separate unit, which may be run as an ordinary dynamo by an engine of from three to six horse power. Operated in this way it may be made to supply a projection arc. The other half, which is merely an ordinary D. C. motor, may be removed from its base and used as a regular motor for any purpose desired.

We do not find it practical to give wiring diagrams for this class of apparatus, because the diagrams vary for different voltages and these sets are usually built to specification to suit the purchaser. We would therefore recommend that the wiring diagrams which accompany the set be carefully put away and kept for future reference.

The Hallberg D. C. to D. C. motor generator is also made in a new, more modern design, illustrated in Fig. 166. This machine has only two bearings, both of which are ball bearings. The various machines have outputs ranging from 25 to 150 amperes. With this type of motor generator the manufacturer will furnish controller panels, including the necessary voltmeters, and ammeters for double arc operation where the generator capacity is 70 amperes or more.

INSTRUCTION NO. 1. INSTALLATION.—(See General Instruction Nos. 1 and 2.)

INSTRUCTION NO. 2. CONNECTIONS.—All electrical connections should be made as shown in the wiring diagram accompanying each machine, and they must be clean and tight. Fuses should not have a higher capacity than that indicated by the diagram.

INSTRUCTION NO. 3. BRUSH TENSION.—After the machine has been properly set and connected, rotate the armature by hand and examine each carbon brush to make sure that it moves freely, without the slightest friction, in the brushholder. Make sure that the flexible copper cable, or pigtail as it is called, is properly clamped by the screw in the brushholder casting. When the brush moves freely in the holder, the next thing to receive attention is the tension spring which holds the brush against the commutator. See General Instruction No. 8. The pressure exerted by the brush tension spring may be varied by changing the end of it to different notches provided in the brushholder casting. Any required degree of tension can be had by using the different notches.

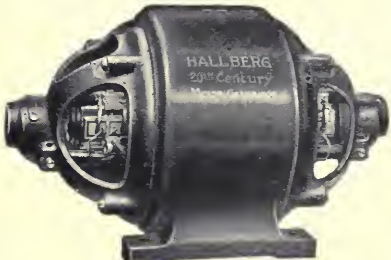


Figure 166.

INSTRUCTION NO. 4. OILING.—The oil chambers should contain enough oil to give the rings (see Fig. 148) a good dip. The oil level may be seen in the gauge on the sides of the bearings. It should be at the top of the gauge. When starting the machine, lift oil chamber covers and see that the oil rings are turning freely and carrying oil to the shaft.

The old oil should be drawn off every month or two. This is done by unscrewing the drainage plug at bottom of the bearing. After draining off the oil replace it with new. See General Instruction No. 3.

SPECIAL INSTRUCTION FOR BALL BEARINGS.—The latest type D. C. to D. C. motor generator, Fig. 166, is equipped with ball bearings. See Instruction No. 7. for Hallberg's Twentieth Century Motor Generator Set. For removing ball bearings see Instruction No. 8 under the same heading, the ball bearings of the two machines being of the same type.

INSTRUCTION NO. 5. SETTING OF BRUSHES.—Machines are shipped from the factory with the brushholders and brushes properly set. The position of the brushes is approximately half way between the poles. In the motor, they are placed one or two segments back (that is, against the direction of rotation) of the exact middle or neutral point, while in the generator they are set one or two segments forward. The brushholders should be placed on the studs in such position that the brushes in different holders will not run in the same line on the commutator. This will help to avoid grooving.

INSTRUCTION NO. 6. STARTING SET.—First see that the starting box lever has moved to the off position. If there is a regulating rheostat on the motor end, its handle should be moved as far as possible in a contra clockwise direction. If there is one on the generator end its handle should be moved as far as possible in a contra clockwise direction. Close the main switch and move the lever of the starting box over the contacts, leaving each one for about one second, until it is against the magnet, which will hold it. If the set has not started when the fourth contact point is reached, immediately open the main switch and ascertain the trouble. When the set is running the current may be adjusted by means of the regulating rheostats.

INSTRUCTION NO. 7. STOPPING SET.—Open the main switch and let the starting box operate itself. The lever will be released when the motor has slowed down, when it will, or should, fly back to the "off" position. If the contacts become rough and prevent the lever from moving all the way back, they should be smoothed up with No. 0 or 00 sandpaper. **The lever must never be fastened or allowed to stick at an intermediate point.**

INSTRUCTION NO. 8. CARE OF BRUSHES AND COMMUTATOR.—(See General Instruction No. 8.)

HALLBERG'S TWENTIETH CENTURY MOTOR GENERATOR SET.—J. H. Hallberg, New York, puts out a motor generator set, known as the "Twentieth Century Motor Generator," shown in Fig. 167. The machine occupies a floor space 15 by 31 inches, and is 15 inches in height. Its weight is a little less than 500 pounds in the 70 ampere size, the 40 and 130 ampere machines being respectively less and greater in weight. The machine is compact, rigid in construction, and its parts are easily accessible for adjustment or repair, as may be seen by an examination of the various plates.

The machine is made in capacities of 20-40 amperes, 30-70 amperes, and 60-130 amperes. The 30-70 ampere size is the

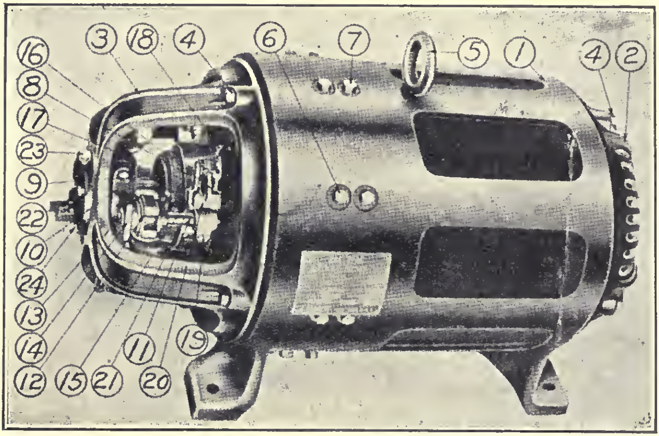


Plate 1, Figure 167.

capacity more largely in demand for moving picture work, in that it will operate with a fair degree of efficiency on a 30 ampere load, and will carry two 50 ampere arcs for the short period of time necessary to make a change from one projector to the other. It must not be understood from this that the generator should be allowed to carry a 100-ampere load for more than one to one and a half minutes.

The machine delivers direct current to the arc, at arc voltage, without any resistance interposed in the circuit, which means, of course, that it is a specially compounded generator, and, to go a little further, a specially compounded generator pulled by an A. C. motor, the two armatures being mounted on one shaft, and contained in one housing, with a ball bearing at either end of the shaft.

Plate 1 supplies a view of the whole machine, with the various parts numbered.

NO. 1.—LUBRICATION.—The lubrication of this machine differs from that of most other motor generator sets used for moving picture work, in that grease is used instead of oil.

The grease chambers may be filled in two ways: First, if you have purchased your grease in a "gun," or if you have a "gun" which can be filled with grease, having removed screw, 23, Plate 1, and a similar one on the opposite diameter of the grease chamber cover, you can place the spout of the gun in the upper hole and force grease in. This will force the old grease out at the lower hole, and the job will be a fairly complete one. This operation must be performed for the grease chamber at each end of the armature shaft. When through you will, of course, replace the screws.

Another way is, if you have no grease gun, to remove screws 24 (four of them) on the end of the cast iron cap which covers the grease chamber. You can then pull the cap off, clean out the old grease, and pack the chamber with fresh lubricant. It would be well to wash out the grease chamber thoroughly with kerosene or gasoline after the old grease is removed.

Still a third way is to remove screw, No. 23, Plate 1, and insert in lieu thereof a compression grease cup having a stem of the same diameter and thread as a ⅛-inch gas pipe. Where the compression grease cup is used when it is desired to force grease in it will be necessary first to remove the screw in the opposite diameter to screw 23, Plate 1, same being immediately below the grease cup, in order to allow an equal amount of old grease to flow out. Where the compression grease cup is used it is merely designed that the cup take the place of a grease gun—therefore it should be a large one and only used to force a large quantity of grease in about once every 60 to 90 days, it being expected that when the run is, say, twelve to fourteen hours per day one greasing will last for that length of time.

CAUTION.—Don't use any and every kind of grease. The grease serves ball bearings, and if it contain alkalis or acids you may expect trouble and plenty of it. For this reason our advice is: **Use only grease procured from the manufacturer of the machine.** You may regret it if you do otherwise.

NO. 2.—LOCATING THE MOTOR GENERATOR.—(See General Instruction No. 1.)

NO. 3.—INSTALLATION.—(See General Instruction No. 2.)

NO. 4.—CLEANLINESS.—(See General Instruction No. 4.)

NO. 5.—LOOSE CONNECTIONS.—(See General Instruction No. 6.)

NO. 6.—AMMETER AND VOLTMETER.—(See General Instruction No. 7.)

NO. 7.—REMOVING END BEARING BRACKET 2, P. 1.—It will never be necessary to remove this bracket unless some fault should develop through the use of improper grease, or a very improbable inherent imperfection in the ball bearings, but should such a thing occur you may remove end bearing bracket 2, P. 1, by first removing four hexagon shaped nuts, holding the cast iron cover of the grease chamber. These nuts do not show in the plates, but correspond to nuts 24, P. 1, in the grease chamber cover at the opposite end of the machine. The studs, which are held by four hexagon nuts, not only hold the outside cast iron cover to the grease chamber, but extend through and into an inside cast iron grease chamber cover. The ball bearings are clamped between these two end covers, and these bearings should never be removed from the armature shaft except it be desired to install a new bearing. Therefore, after having removed the hexagon nuts and the outside cover, using a copper punch and hammer, gently drive the studs inward to loosen the inside cover. Having done this, remove bolts 4, P. 1 (four of them), whereupon you may pull away end bearing bracket 2, P. 1.

NO. 8.—TO REMOVE THE BALL BEARING at the A. C. end of the armature, follow Instruction No. 7. Having done so you will see on the end of the shaft a nut having in its edge a saw kerf, and in its face the head of a machine screw. This screw acts as a lock nut by compressing the edges of the nut where the saw kerf is made, thus locking the threads to the shaft. Loosen it and remove the nut, which has a right-hand thread. This will release the ball bearing, which may be pulled out. When installing the new ball bearing or replacing the old one, **be sure and get it on the shaft straight or "square."** If you attempt to put it on a slant it won't go, but if started on just right will slip on easily. Having it in place, **set up the lock nut as tight as you can get it,** and then set up the screw in its face, thus locking the nut to the shaft. In replacing end bearing bracket 2, P. 1, proceed carefully, and don't try to force it on over the ball bearing. When you get it exactly right it will slip on without any trouble whatever. If it does not do so, that is your fault and **not** the fault of the bracket—you have not placed it exactly in the right position with relation to the bearing. If you try to force it on you will probably succeed in ruining the ball bearing. The rest of the process of replacing is simply the reversal of the process of disassembling.

NO. 9.—TO REMOVE THE ARMATURE lift out all the brushes, 17, P. 2. To do this lift finger 9, P. 3, and pull the brush out, letting it hang by its pig tail so that you will be sure to get it back in the right holder. Next remove bolts 4, P. 1 (four of them). Next remove the four hexagon-headed bolts, 24, P. 1, holding grease cover cap, 22, P. 1, and

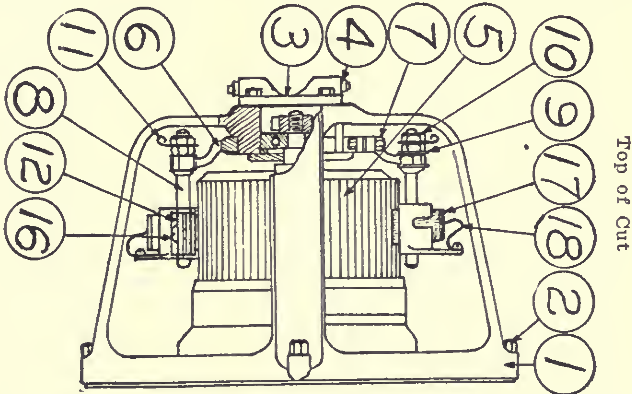


Plate 2, Figure 168.

pull the armature, carrying end bracket, 2, P. 1, with it, straight out at the A. C. end.

CAUTION.—Never lay an armature down flat on anything. Either stand it on end, or else support it on two chairs or boxes, using the ends of its shaft for the purpose. If you lay the armature itself down on the floor or table you are likely to injure the insulation. The replacement of the armature is simply a reversal of the process of taking it out, doing each step in its turn.

NO. 10.—TO REMOVE THE COMMUTATOR END BEARING BRACKET, 3, P. 1, first remove four hexagon-headed bolts 24, P. 1, in grease cover cap, 22, P. 1. Next lift out all the brushes. They may be lifted out by raising finger

9, P. 3. Let them hang by their pig tails, so that you will get them back in the right holder. Remove bolts, 4, P. 1 (four of them), whereupon the bracket may be pulled away.

CAUTION.—The four hexagon-headed bolts extend through and hold the plate covering the inside end of the grease chamber. This cover will sometimes stick slightly. Before removing the bolts, but after having backed them out for three or four turns, tap on them lightly with a hammer, in order to loosen the inside grease chamber cover.

NO. 11.—TO REMOVE BRUSH YOKE, 6, P. 2, follow Instruction No. 10, then loosen screw, 7, P. 2, whereupon you may pull away the yoke, carrying all the brushholders.

NO. 12.—BRUSHHOLDER STUD.—Should it ever be necessary to remove brushholder stud, 8, P. 2, it may be done by loosening nut, 10, P. 2, but if you do this, be very careful in reassembling that the insulation, which consists of two mica washers, 9, P. 2, and a mica sleeve around the bolt, be not in any way injured. If this insulation is not perfect, then the whole frame of the machine will be charged with potential. In loosening these parts it will be well to remove nut 10, P. 2, and thoroughly clean the contact between it and the copper clip to which the wire is connected. In reassembling be sure to set up nut 10, **tight,** else you will not have good electrical contact; also it is essential that the lock nut behind nut 10, which holds the insulation in place, be set up tight, else the brushholder stud will vibrate and thus cause trouble.

NO. 13.—BRUSHHOLDER, 12, P. 2, may be slipped off at any time by loosening screw 16, P. 2. Before taking off the brushholder you should make a scratch mark at its end on the stud, so that in reassembling you may get it back in exactly the same position it formerly occupied.

NO. 14.—CARE OF THE COMMUTATOR.—(See General Instruction No. 8.)

NO. 15.—TO INSTALL NEW BRUSHES.—First raise finger 16, P. 1 (shown better at 9, P. 3), and remove the screw holding the end of the pig tail to the brass casting, then lift out the brush, put in the new one and attach its pig tail to the casting the same as the old one was. **The face of the new brush must be ground to fit to the curve of the commutator.** To do this lift out all the brushes you are not replacing, then place on the commutator, sand side out, a strip of No. ½ sandpaper long enough to extend one and one-half times around its circumference. Lower the new brush on this sandpaper under the pressure of its tension spring, and revolve the armature by hand, or by pulling a long piece of heavy cord bound around the commutator one or two times, until the brush is ground down to a proper bearing. It is also possible to lay a piece of sandpaper on the commutator and pull it back and forth, but the other way is the better. Do not apply power to the motor for grinding brushes.

NO. 16.—HEATING.—(See General Instruction No. 11.)

NO. 17.—GENERAL REMARKS.—Plate 3 shows the construction of the brushholder in detail, 14 being the pig tail, 11 the spring which governs the amount of tension supplied the brushes through finger 9, P. 3. Plate 4 shows the pole piece construction, main poles A-A being wound and B-B not wound. In like manner interpoles or "commutating poles" C-C are wound, while D-D shows the core of the poles without the windings. The machine is entirely self-contained, and requires no special base. It may either be set on a cement floor and bolted down or on any other reasonably solid foundation, but if installed in the projection room it should be set on a small rubber pad or heels of good live rubber. This will take up all vibration, make the machine practically noiseless, and there will be no necessity for bolting it down at all.

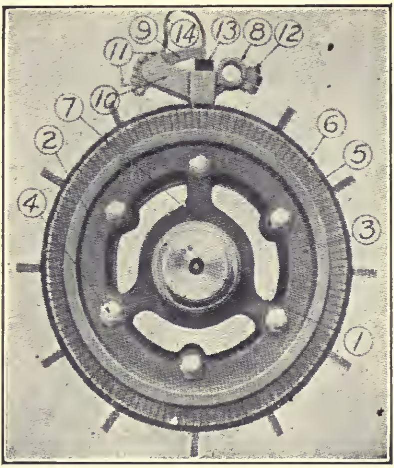


Plate 3, Figure 169.

The efficiency of the machine is claimed by the manufacturer to be between 65 and 70 per cent., depending upon local conditions and the degree of intelligent care given.

The accompanying connection diagrams are quite plain, and may, I believe, be followed without any trouble by the average well-posted projectionist. Plate 5 shows the various connections for single, two and three phase 110 or 220 volt circuits.

All Hallberg Twentieth Century A. C. to D. C. motor generators are so wound that they may be used either for 110 or 220 volt current, merely by changing the connections as shown in P. 5.

TWO-ARC MACHINE.—P. 6 shows the wiring of the D. C. end, with two projection arcs connected in multiple with each other. By this arrangement arc No. 1 may be operated at any desired amperage between 30 and 60 by moving the handle of the field controller. When it is desired to start the second arc and fade the first picture into the next, the operating or machine switch on machine No. 2 may be closed, and when the time comes to swing over to that machine its arc is started merely by bringing the carbons together and separating them in the usual manner, which will automatically extinguish the arc of machine No. 1, thus fading one picture into the next. This is a matter which will require some practice, but once it is mastered it is quite possible to secure fair results. But where this plan is used the projectionist will do well to burn craters on his carbons when there is no picture on the screen. In other words, he should have a supply of burned-in carbons. It will probably also be found necessary to recenter the upper crater by raising the lamp about one-quarter of an inch before starting the arc.

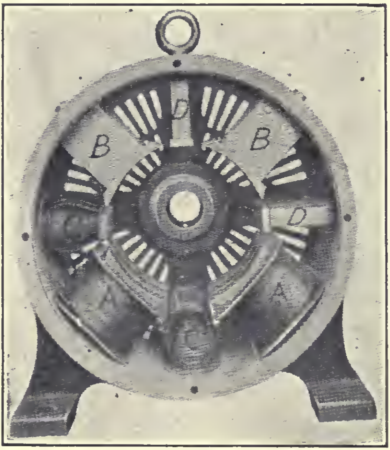


Plate 4, Figure 170.

The projector motor must, of course, be started just before the arcs are changed over. The manufacturer claims that one of the peculiarities of this generator is that it picks up and steadies its arc almost instantly.

P. 7 shows the generator with its control panel (Panel Z) connections arranged for single and double arc operation. When the handle of the switch is down, the connections give the same results as those of P. 6, but ammeters and voltmeters are added, so that the current may be adjusted by the field rheostat to any desired value within the limits of gener-

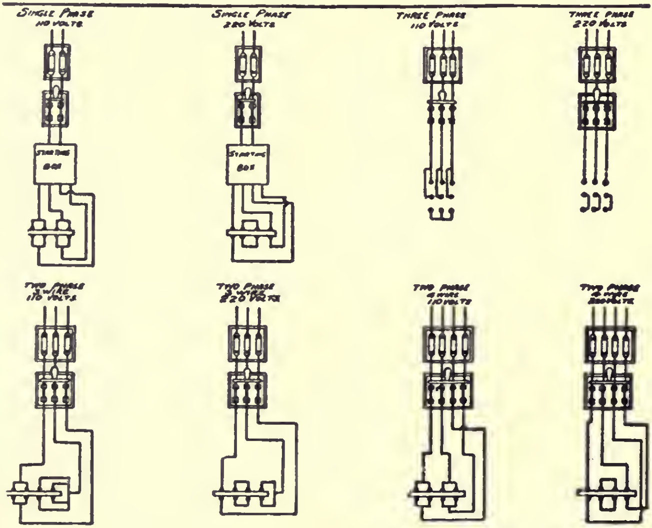


Plate 5, Figure 171.

ating capacity. In this position the compound winding connected to C1 and C2, opposes the shunt field, which causes the generator to produce constant current for the operation of one arc at a time, in which case no resistance is necessary in series with the arc, the generator having within itself the necessary flexibility to properly control the arc.

By comparing the front and side views of the panel, it will be seen that C1 and C2 represent the hinge clips of the switch, and are therefore common to both its down and up positions. In the down position one switch blade connects

C2, L1 and L2, and the second blade C1 and A+. Let us assume that lamp 1 is burning, then the flow of current starting with A+ at the generator to A+ of the panel, from there to C1 through the switch blade, thence to C1 of the generator through the series field back to C2, thence to L1 through the other switch blade, to the projector switch controlling the arc, back from the arc through the negative connection, thence to L1 L2 of the ammeter shunt, to A— of the shunt, the armature terminal of the generator, and after passing through the armature it again flows out of A+ and the process repeats itself. The circuit would have been the same if we had assumed lamp 2 burning, instead of lamp 1, except that the current would have passed from C2 to L2, instead of L1.

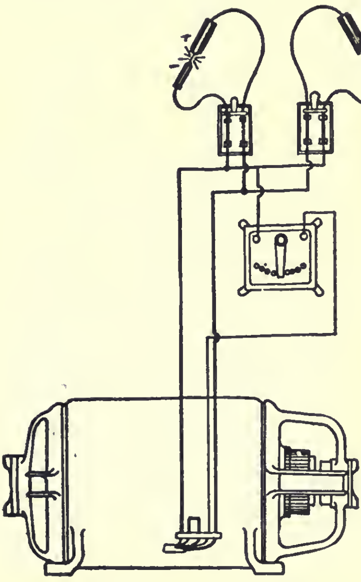


Plate 6, Figure 172.

The shunt field terminals F, F, respectively, are connected to one armature terminal at the machine, A—, and to the other through the field rheostat on the panel to A+. When it is desired to operate the two arcs at one time, the switch handle must be thrown to the up position, which connects in each arc circuit the necessary ballast resistance, reverses the current through the series field, so that the series and shunt fields assist each other and short circuits the terminals of the rheostat, these last two connections resulting in the generator producing maximum voltage.

With two arcs burning there is a voltage drop of 5 to 6 volts in each resistance, and under certain conditions, as when large fluctuations of line voltage occur, it may be found desirable to operate the arcs with the switch in this position, even when only one arc is burning. The highest efficiency, however, is obtained with the switch in the one-lamp position, and the two-lamp position is only intended to allow for more perfect dissolving when changing from one projector to another.

The flow of current for the two lamp position of the switch, considering first, lamp 1 as burning, would be from the positive armature terminal A+ to A+ on the panel board, which by a cross connection brings the current to the top left hand terminal, thence through the switch blade to C2, thence to C2 the series field terminal at the generator, through the

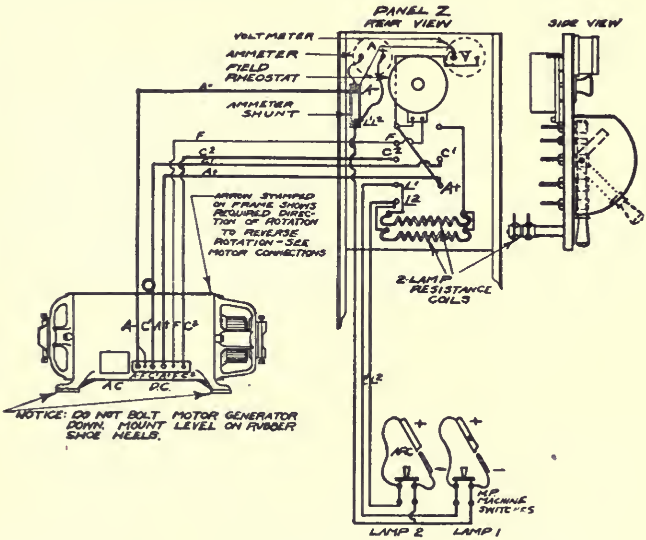


Plate 7, Figure 173.

series field to terminal Cl, thence to Cl on the panel, through the switch blade to top right hand switch, thence to common ending of ballast coils, through top ballast coil to Ll, thence to positive side of lamp 1 projector switch, through the arc back through the negative side of projector switch, thence to L1 L2 of ammeter shunt to A—, thence to negative armature terminal A—, through the armature and out again at A+, after which the flow of current continues as before. The reversal of current through the series field is accomplished by the cross connection of A+ on the panel, and the left hand top switch blade short circuits the rheostat terminals F and A+, cross connected terminal.

If lamp 2 is also burning then current will also go through the bottom resistance coil to L2, thence to lamp 2 and back through the negative connection to L1 L2 of the ammeter shunt, and back to the generator as before. In some panels the ammeter shunt is mounted on the terminals of the ammeter, so that L1 L2 becomes one of the ammeter terminals.

HALLBERG SERIES ARC MOTOR GENERATOR.— Within the past few years there has been developed and put into service a modified form of the old series D. C. Arc dynamo, the generator automatically adjusting itself to deliver from 40 to 60 volts to each one of the arcs. With this system, when all lamps are off, their terminals short circuited with a switch, and the generator operating, when one short circuiting switch is opened (carbons of that lamp being in contact) and the carbons are separated, the arc will be struck and the generator will automatically supply the required number of volts for maintaining the arc, regardless of the carbon separation or arc resistance, within reasonable limits, of course. A second lamp may be similarly switched on, whereupon the generator instantly and automatically supplies exactly the additional voltage required for the added resistance of the second lamp.

For motion picture projection, where not more than two arcs are required at one time, it is possible to use this scheme without introducing any movable regulating devices, and it is not necessary to shift the brushes, because by properly designing the magnetic circuit and by a proper arrangement of the shunt and series field it is possible to give practically constant current from such special generator, regardless of whether one or two arcs are burning.

The Hallberg Series Motor Generator, illustrated in Fig. 174, is of this type. It is of the horizontal type, meaning by this that its armature shaft is in horizontal position. The A. C. armature, or rotor, and the D. C. armature are mounted on one short, heavy shaft, which is supported at either end by two large double-row, self-aligning ball bearings. Unlike the Hallberg motor generators hereinbefore described the A. C. motor frame is made in a separate unit, which is bolted to a bored and faced-surface on the generator field frame. This construction is, when assembled, to all intents and purposes one solid frame, but with the advantage that it is very easy to separate the A. C. end from the D. C.; also it permits of very efficient ventilation, and decreases the weight of material required for a unit of given output.

The machine may be had for 25, 33, 40, 50 and 60 cycles, and either for single, two or three phases in the same frame. The machine is now standardized, and obtainable in the following sizes, viz.: double 50 ampere, which is adjustable from 40 to 60 amperes; double 75 ampere, adjustable from 60 to 85 amperes; and double 120 amperes, adjustable from 75 to 135 amperes, all three types operating either one arc or two arcs in series.

With this type the wiring is simple, there being required one loop from one terminal of the generator through the first projector switch, then through the second projector switch, and through a third, if it is a three-projector installation, the switch of the last projector being connected to the other terminal of the generator.

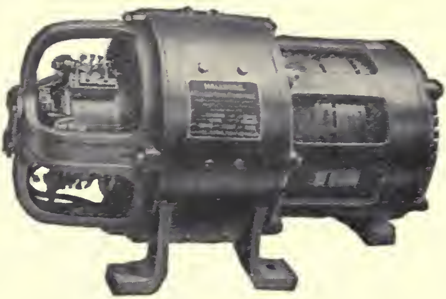


Figure 174.

The diagram, Fig. 175, illustrates the very simple connections between the motor generator, the instrument panel, and the projector table switches, it being understood that if three projectors are installed, it merely means extending the loop of the circuit to include an additional projector table switch.

The over-all dimensions of the Hallberg Series Arc Motor Generator referred to is thirty inches in length, by about twenty-two inches diameter for the largest size. The weight varies from 450 to 650 pounds, depending upon the capacity of the set, and the phase for which the machine is made, the heaviest being the 120 ampere capacity machine, wound for 25 cycles, single phase current.

Some theatre managers insist upon complete duplicate motor generator installation. For such a demand the Hallberg motor generator is made with different winding, so as to provide the maximum number of amperes required for the operation of one arc only, and then two motor generators are installed as per Fig. 176, connected to a set of transfer switches and bus-bars, with one instrument panel and a field rheostat for each generator. This installation is so arranged that either one of the generators may operate either one of the two arcs merely by operating two switches, or both generators may be made to supply double the current to either one of the arcs.

The instructions for the setting, care and operating of the Series Arc Motor Generators are in every way the same as those given for the Hallberg Twentieth Century Motor Generator sets, page 490, with the single exception of instruc-

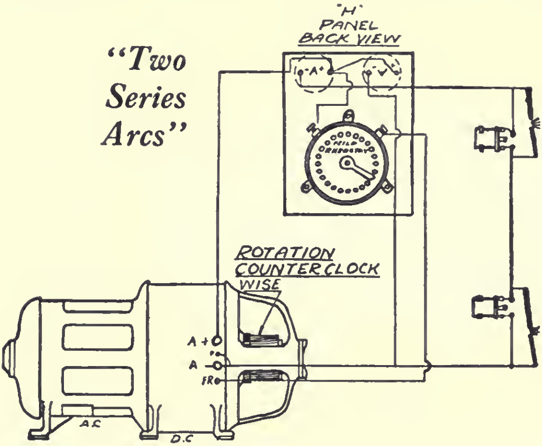


Figure 175.

tion No. 9, Page 493, which for the Series Arc machine should be as follows:

TO REMOVE ARMATURE.—First make certain that all electrical connections are broken, so that no parts will be carrying current. If the connections between the set and the line are broken at the set before the disconnections are made, the ends that will be separated should all be marked so that when the connections are re-established they will be correctly made. However, coiled motor leads of 20 inches or more length will obviate the necessity of doing this, or opening the main switch will suffice if the complete set need not be moved from its position in order to make the armature accessible.

The next thing is to lift the brushes on the generator side out of the brush holder boxes, care being taken that in this process the position of the brush rocker is not changed. It is also necessary to mark the side of the brushes which is towards the direction of rotation, so that when the brushes are put back in their respective holders they will be put in with the same side forward. This will insure good contact when the set is reassembled.

Next, remove the cap screws and the outside ball bearing caps on both the motor and generator ends. Then remove the cap screws which hold the bearing bracket to the motor frame on the alternating current side, and then remove the bracket complete. This can be done without taking the ball

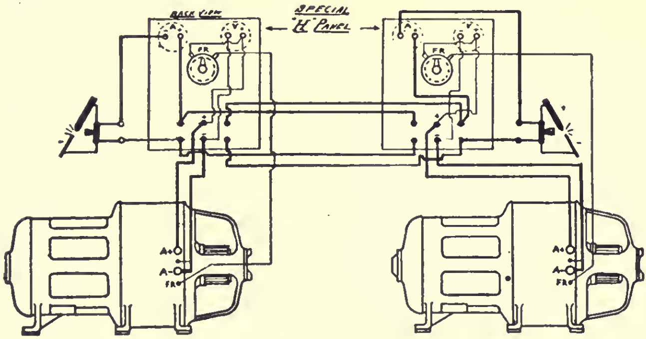


Figure 176.

bearing off the rotor shaft. Next remove the cap screws which fasten the motor frame to the generator frame, and then completely remove the motor frame.

After this has been done the armature can be slid out of the Generator. Care, however, must be taken in doing this, so that the direct current armature winding will not be scratched or in any other way damaged. The armature being out of the machine, in order to remove the ball bearings and inside caps so that they can be employed on a new armature, which it is assumed is to be installed, the following procedure should be followed. Loosen the small screw in the split portion of the ball bearing clamp nuts, and then turn the ball bearing clamp nut to the left, using a hammer and blunt chisel, placing the chisel against the lugs of the clamp nuts. When the clamp nuts have been removed the ball bearings are to be pried off the shaft, and after that the inside ball bearing caps can be removed.

The middle fan of this set is made in two halves. To remove it it is necessary to loosen a screw on one side of the split casting, then remove the screws which hold the castings to the shaft itself. The fan can be opened like a hinge, removed and made available for mounting in exactly the same manner on the shaft of the new armature.

In re-assembling the set the reverse of the process described should be carried out. The first thing to do is to place the inside ball bearing caps on the new armature shaft, first determining by the conditions of the felts in the grooves of the caps whether or not new felts should be inserted. The ball bearings are then placed on the shoulders on the shaft provided for that purpose. The clamp nuts are to lock the ball bearings in position, and the importance of putting those clamp nuts on very tightly must be emphasized. It cannot be satisfactorily done by turning the clamp nuts in position with a wrench. It must be done with a blunt cold chisel and a hammer. The hammer blows should be heavy, so that the nut will be positively locked hard up against the ball bearing race. The clamp nuts are made of malleable iron and will not crack. After the lock nuts are driven on tightly, as described, the screws in the split portion of the lock nut should be set positively and securely. **Only clean grease of a kind recommended by the manufacturer should be put on the inside of the ball bearing.**

The armature is then ready for insertion in the generator frame, and the component parts re-assembled in reverse order as previously described for the dis-assembly. Care must be exercised to in no way subject the windings to injury by contact with other parts. After the assembly has been made and the bearing brackets are in position, before putting on the outside end caps fill the bracket housings with ball-bearing grease. Tighten the ball-bearing cap-screws firmly. After this re-insert the brushes on the generator in the position which they occupied before removal.

Motor-generator sets shipped complete have a mark indicating the proper position of the generator brush rocker. It is possible that a new armature will not operate as successfully as the original armature with the brush holders set in accordance with this painted mark. In that event it will be necessary to move the brush rocker slightly in one direction or the other, to first get the point of sparkless operation under load; second, if the full volt and ampere output is then not obtained the rocker may be moved slightly to give the desired results while the arc is burning and field rheostat three-quarters out if machine is cold. This shifting of brush position, however, should never exceed a distance more than the width of from one-half to one commutator bar.

THE WOTTON VERTICAL REXOLUX.—This machine is made by the Electric Products Company, Cleveland, Ohio. It was the first vertical type (armature standing on end) motor generator set used for motion picture projection work. The Rexolux receives A. C. at line voltage, and delivers D. C. to the arc, at arc voltage, without resistance in series and the loss incident thereto.

The machine is built in three sizes, viz.: One designed to operate a single lamp; one to operate two lamps alternately, and one to operate two lamps continuously. Where two lamps are operated continuously, only the 70 ampere machine is available.

The 50 ampere machine, of either MA, or twin type (the meaning of these different types will be explained later on) occupies a floor space 17 by 20 inches, and has a vertical height of 34 inches, to the top of cap 14, P. 1. The switchboard, supported by angle irons, is immediately over the machine, so that the entire space required for the 50 ampere equipment is 17 by 20 inches on the floor, by 5 feet in vertical height. The

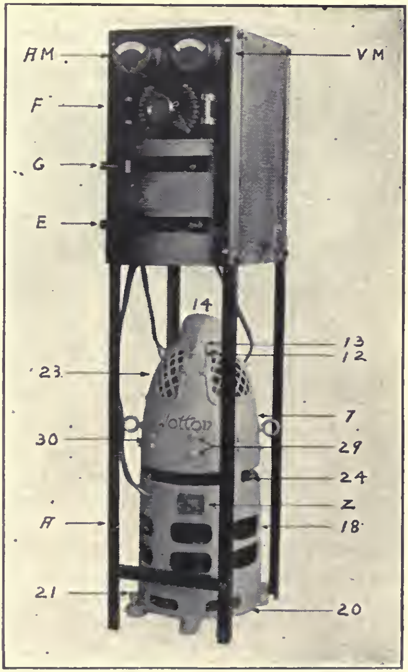


Figure 177.

35 ampere machine is 3 inches less, and the 70 ampere is 3 inches greater in height, but the floor space required is practically the same for all the types.

In referring to ampere capacity the ratings are based on continuous operation. The 35 ampere machine will carry 50 amperes, the 50 ampere machine 70 amperes and the 70 ampere 90 amperes for short periods of time. This means that these machines will carry full load continuously, and stand the overload named for short periods, say not exceeding two or three minutes.

These machines are built for all standard voltages and frequencies, viz.: 110, 220, 440, and 550 volts; 25, 30, 40, 50 and 60 cycles, single, two and three phase.

CONSTRUCTION.—Referring to Plate 2, Fig. 178, it will be seen that the machine consists of four main castings, viz.: Base casting 20, which rests directly on the floor and

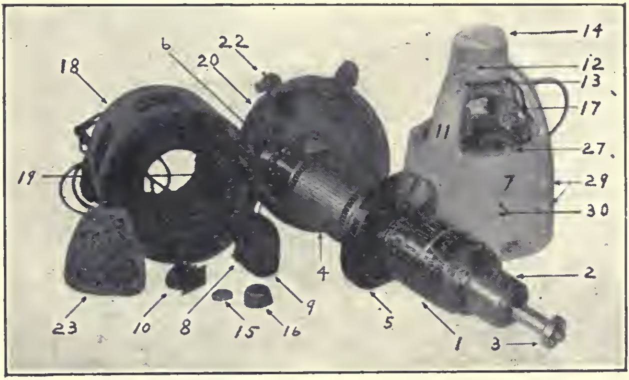


Plate 2, Figure 178.

contains in its center the cup or depression carrying ball race 6, which supports the entire armature; casting 18, which rests on base 20 and forms a housing for the alternating current driving motor, the detailed construction of the windings of which are plainly seen at 19, Plate 2; main upper casting 7, which supports the pole pieces of the D. C. generator, and upper yoke casting 11, carrying grating 23, the upper armature bearing, and cap 14, Plate 1; main upper casting 7, Plate 2, and yoke castings 11, Plate 2, are held together by bolt 27, Plate 2, dividing at the dotted line.

The armature stands vertical (on end), with the rotor of the alternating motor, 4, Plate 2, below, fan 5 above rotor 4, and armature 1 with commutator 2, above the fan. The upper end is supported laterally by a ball bearing, the construction which is shown in detail in Plate 3, Brush holders and brushes 17 are shown in Plate 2.

The details of upper bearing 3, Plate 2, are shown in Plate 3, in which 4 and 5 are, respectively, an exterior and interior ball race, separated by steel balls 6, part 5, the interior race being clamped rigidly to shaft 9, by means of nut 2. Part 4 is stationary and sets in a recess in the main frame casting,

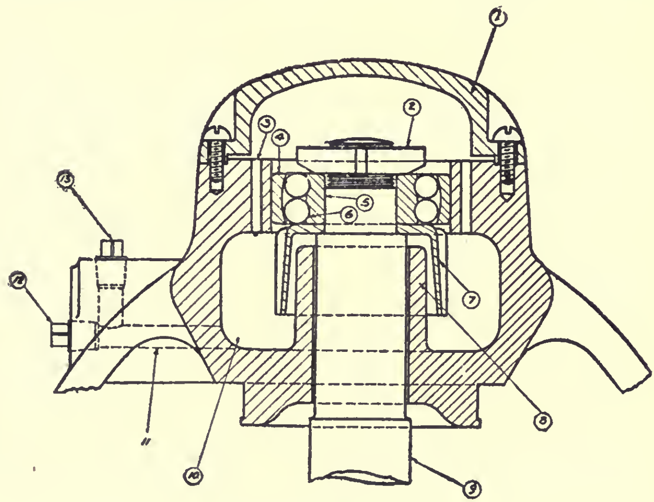


Plate 3, Figure 179.

the whole being covered by cap 1. Part 7 consists of a casting which is clamped between interior ball race 5, and the shoulder of shaft 9, so that it must revolve with the shaft at armature speed. This part (7) extends down into oil well 10. The oiling action is as follows: Oil well 10 is filled with oil up to approximately one-quarter inch of the top of the passage containing plug 13. Part 7 revolves at high speed, and, by the centrifugal action thus created the oil is forced up through passage 3-3, whence by gravity it returns again to the well through the bearing, thus flooding balls 6 with a continuous stream of oil.

Thirteen, Plates 1, 2 and 3, is a plug closing the passage through which oil well 10 is filled. **It is essential that this plug be in place and screwed tightly home, else the centrifugal action before named will force the oil out and empty the well.** Plug 12, Plates 1, 2 and 3, is for the purpose of draining oil well 10, and **this should be done at regular intervals every thirty days.** After draining the oil well insert plug 12 and fill the well with kerosene, start the machine and let it run for, say, two minutes, after which drain all the kerosene out, replace plug 12 and fill the well up with lubricating oil to within one-quarter inch of the top of the passage stopped by plug 13.

As the quality of oil to be used, see General Instruction No. 3, but:

CAUTION.—Never, under any circumstances, use the much advertised patent oils, as they almost without exception are worthless for the lubrication of heavy or high speed machinery. The use of such oils will invalidate the manufacturer's guarantee.

On the other, or lower end of the armature shaft, is ball bearing 6, Plate 2, lubrication for which is furnished by grease cup 21, Plates 1 and 2. This grease cup should be kept filled with Alco Grease.

CAUTION.—It is important that either Alco Grease or some other high grade cup grease be used, because of the fact that if a grease containing any acid is used in cup 21, the acid will attack the steel balls, and in course of time destroy their accuracy, thus compelling an unnecessary and somewhat expensive renewal of the bearing.

ARMATURE.—The armature or revolving member of the machine is completely assembled into one solid part, 1 to 6, Plate 2, in which 3 is the upper and 6 the lower bearing. The alternating current rotor, or revolving member, 4, is built up of reannealed electrical sheet steel, properly punched and assembled on armature shaft 9. The rotor bars are driven through the slots a tight fit, the ends electrically welded together into a solid mass of pure copper, which insures perfect contact, low resistance and a uniform torque, or pulling force. Directly above the rotor is fan 5, Plate 2, made of sheet steel blades and a solid ring, the blades riveted and welded together, and finally attached to shaft 9 by means of two heavy set screws. This fan produces a suction through the ventilating openings in castings 18 and 20, drawing cold air over the windings of the A. C. motor. This air is then forced up over this D. C. armature, and out through openings 23, Plate 1.

Part 1, Plate 2, is the D. C. armature, which is mounted directly above fan 5. Armature coils are fixed in place with retaining band wires where the connections are made to commutator 2, Plate 2. The commutator is made up of hard drawn copper segments, insulated with mica, and held in place with steel rings clamped with four bolts. The D. C. generator is of the four-pole type, and is provided with commutating or inter poles.

BRUSHES.—The setting of the brushes is shown in Plate 4. There are four brush studs, 17, Plate 1, and two brushes to a stud. These brushes are attached to the holders by copper "pigtails." Particular care should be exercised to see that the screw holding the pigtail to the brush holder is kept set up tight, because unless the pigtail makes good contact with the holder, the tension spring will be compelled to carry current, which would probably heat the brush spring and destroy its temper.

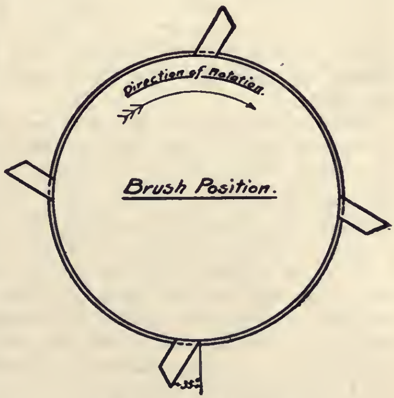


Plate 4, Figure 180.

With regard to the amount of tension the brushes should have see General Instructions No. 7.

The brushes are held in place by a curved arm passing around the holder, ending in a tension finger fitting on the top of the brush. The brushes are held to the commutator **against** the direction of rotation. The amount of tension can be adjusted by the spring and ratchet on the side of the brush holder.

CARE OF COMMUTATOR.—With regard to the care of the commutator, see General Instruction No. 7.

The A. C. driving motor is the induction type, and is built either for single, two or three phase current, but the same machine will not operate on different phases. All standard machines are built to operate on both 110 and 220 volts.

INSTALLATION.—See General Instruction Nos. 1 and 2.

The Rexolux is so built that it may be readily disassembled, since owing to its weight it would in many cases be difficult to hoist it in place in a projection room as a unit. In order to disassemble the machine, proceed as follows:

First, open gratings 23, Plate 1, and remove the commutator brushes from their holders, allowing them to hang by their pigtails so that you can make no mistake in getting them back into their proper holder. Remove screws 26, holding cap 14, Plate 1. Remove nut 2, Plate 3. Remove nuts 24, Plate 1 (three of them) holding main upper casting 7, and main lower casting 18 together. Thrust pieces of gas pipe or steel bars through the eye-bolts and lift main casting 7 straight up and off, laying it to one side, but right side up so that oil will not run out of oil well 10, Plate 3. Next carefully lift out the armature, first, however, having provided two blocks or chairs, and **lay the same down flatways on these blocks or chairs, so that the weight is entirely supported by the shaft.**

It is very important that you do **not** lay the armature down so that it rests on the side of the alternating current rotor 4, fan 5, or direct current armature 1, or commutator 2, since any injury to these would be a very serious matter indeed. Handle the armature carefully and use a little good sense, if you wish to avoid trouble. The machine may now be hoisted or carried into the projection room, where its reassembling will merely be a reversal of the process of disassembling. First carefully lower the armature into place, being careful that alternating current rotor 4, Plate 2, be on the lower end. Next replace casting 7, and tighten up nuts 24, Plate 1, tight. Replace top ball races and nut 2, Plate 3, **tightening nut 2 down as tight as you can get it.** Replace cap 14 and screws 26. Rotate the armature by hand to see that it turns freely, after which replace the brushes in their holders, put gratings 25, Plate 1, back into place, and the job is done.

Be sure and wipe the inside of the top casting clean, since if any oil should get on it, it would collect the copper dust from the commutator and might cause a ground on the brush yoke. See that the casting and brush yoke are thoroughly cleaned of all oil and dust before it is put back in place. It would be preferable to wash them with a cloth dipped in gasoline, wiping with a clean, dry cloth afterward.

Bolts 29, Plate 1, hold pole piece 8, Plate 2, which carries coil 9, Plate 2, in place, and should not be removed under any circumstances, unless the coil be damaged and require rewinding. There are four of these pole pieces and eight bolts, two bolts per pole piece. Bolts 30, Plate 1, hold inner poles 10, Plate 2, in place, and should not be removed under any circumstances unless the coil is burned out and requires rewinding.

Remember the switchboard sets directly over the machine, as shown in Plate 1. With each machine there is furnished three cork pads, 2 inches square by 1 inch thick, which are to be placed under the feet of the machine, where they act as a cushion, absorbing noise and vibration. It is not necessary nor do we recommend screwing the machine to the floor with lag bolts. Its weight is sufficient to hold it in place.

ELECTRICAL CONNECTIONS—TYPE MA SINGLE ARC REXOLUX

In Plate 5, lines G-G show the direct current circuits. The current from the positive generator brush passes out at + G, thence over the evenly dotted line to switch B (G, Plate 1), which when closed, connects, after passing through the ammeter, with the positive carbons of the arc lamp. From the negative brush of the generator the current passes through the various interpole coils in series, then out at — G thence similarly up to the negative side of switch B, and thence to the arc. In order to obtain the necessary field regulation, the extra lead from the shunt field is brought through the frame at F, Plate 5, and thence up to the field regulating resistance. The voltmeter is connected across the terminals of the arc at the right hand side of switch B. This completes the direct current connection for the type MA single arc Rexolux.

Were it not necessary to obtain a self-starting motor, in single phase machines, it would then require but one set of windings. In order, however, to obtain the necessary starting torque, a second set of wire coils is superimposed upon the main power coils. This set of starting coils is thrown out of phase with the power coils by inserting in series therewith a starting resistance and reactance, shown opposite starting switch A, Plate 5. The main power coils terminate in the frame at "M1" and "M2," Plate 5, and the terminals of the extra starting coil at T, the other end of which is connected inside of the machine to the main power coils. The lines designated by a dash and a dot constitute the alternating current wiring of the system.

Where two or three phase current is supplied it is not

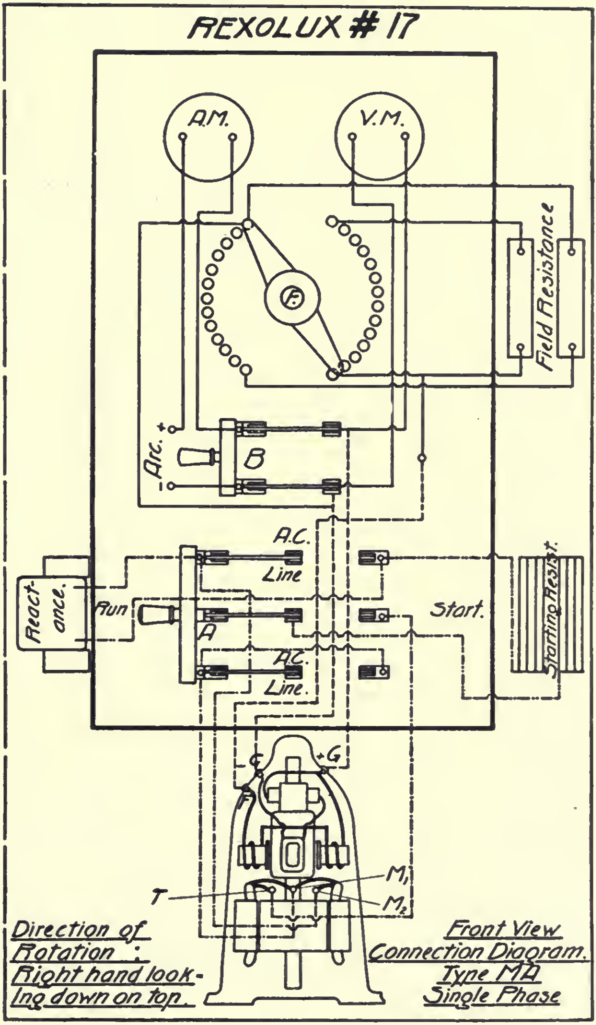


Plate 5, Figure 181.

necessary to use the extra starting coils, or the starting resistance or the reactance. In this case the wiring incident to the starting features of the single phase motor is omitted.

TWO ARC, TWIN TYPE REXOLUX.—The twin type applies to all of those equipments wherein two separate motor generators are used for two projection arcs. Each motor generator is continuously operated independently of the other. Each motor generator is connected to its own projector.

Wherever it is desirable to secure double the capacity of

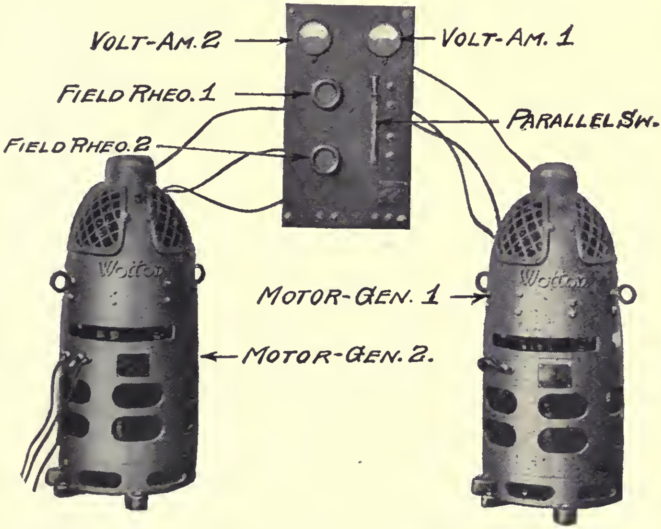


Plate 6, Figure 182.

one machine, the two motor generators can be operated in parallel by closing the paralleling switch. In case one of the motor generators for any reason is out of commission, the two projectors can be temporarily handled by the remaining machine by stealing the arc from one to the other during the change over. By means of these two independent units, one reel can be perfectly dissolved into the other without in any way affecting the picture on the screen. In the operation of the twin type there are no switches on the control panel which need to be opened or closed during the change from one reel to another, or at any other time during the performance, except at its beginning and end. One machine naturally will be running idle while the arc to which it is attached is dead. The actual current consumed by this machine is approximately 350 watts. The opening of the projector table switch not only disconnects the generator from the arc, but opens the field circuit of the generator as well. There is no change over resistance loss with the twin type.

TOO MANY MEN HAVE A WISH-BONE INSTEAD OF A BACK-BONE.

Mercury Arc Rectifier

THE mercury arc rectifier is a device marketed by two manufacturers, the General Electric Company and the Westinghouse Electric and Manufacturing Company. Its purpose is to change alternating current of standard line voltage to direct current at arc voltage, the reduction in pressure being accomplished by means of an auto-transformer, which is an integral part of the machine.

Kindly understand that we have, to some extent, sacrificed strict technical correctness to "understandableness" in the following:

PRINCIPLE OF OPERATION.—The mercury arc rectifier consists essentially of a sealed glass bulb, from which the air has been exhausted, provided with four terminals, A, A1, B and C, Fig. 183. Within this tube is a quantity of mercury, the purpose of which will be explained further on. The two upper terminals A. A1. Fig. 183, are of graphite or other suitable material, the two lower ones B, are of mercury, C, Fig. 183, which is the smaller of the two, being what is known as a "starting terminal." When the bulb is in a vertical position the pools of mercury in terminals B and C are separated, but when the tube is tilted or rocked sidewise to the left, they are brought temporarily into contact, for the purpose of starting the tube into action.

When in its active state the vacuum bulb contains vapor of mercury, which is a conductor of electricity only under certain conditions. Current will readily pass from graphite terminals, A or A1, Fig. 183, into the mercury vapor, and when the arc is burning and the circuit thus completed, will pass from it into mercury terminal B, and thus on through the arc.

Alternating current, however, changes its direction many times in the course of a second of time, and when the direction of flow seeks to reverse itself and pass from the mercury to the graphite terminals, these terminals offer sufficient resistance to prevent it. The graphite terminals thus act as check valves, permitting the current to pass from the graphite into the mercury vapor, into the mercury and on through the arc, but preventing it from reversing its direction and passing into the graphite terminals.

The A. C. supply circuit is connected to graphite terminals A and A1, Fig. 183, through an auto-transformer, which lowers the voltage to that required at the arc, and as the above described action will only allow current to flow in one direction, the pulsations of current which pass alternately from terminal A and A1, Fig. 183, into the mercury vapor must, of necessity, all pass out of the vapor through mercury terminal B, Fig. 183, which is connected to the arc lamp. As a result the arc receives a continuous, slightly pulsating current which differs but little from ordinary D. C. Ordinarily the pulsations would be quite pronounced, but this is prevented by a feature of the auto-transformer (main reactance) which decreases them to such an extent that the current delivered at the arc has a very nearly constant potential value.

Before the bulb starts working it contains no mercury vapor. Within the bulb is a vacuum which must be filled with mercury vapor before current can flow. Once the space is filled with mercury vapor, however, and current flow has been started, it will continue to flow as long as it is uninterrupted, but any interruption, even for the shortest period of time, permits the vacuum to re-establish itself and stops the operation of the bulb.

HOW THE BULB IS STARTED.—In order to fill the bulb with mercury vapor, it is tilted until the mercury in terminals B, C, comes into contact, and since terminals B and C have direct connection with the A. C. supply, through a special circuit, current flows between terminals B and C. The tube is then rocked back to upright position which breaks the mercury bridge thus formed between terminals B and C, and in breaking it forms an arc or spark, which creates the initial current-carrying mercury vapor, and puts the tube into operation. Once started the rectifier will continue to operate indefinitely as long as there is no interruption.

The alternating current supply circuit is connected to an auto-transformer, or main reactance, the terminals of which are connected to the terminals A, A1, Fig. 183. From terminal B the current passes through the arc, and the circuit is completed through a connection to the middle point of the auto-transformer.

The principal parts of a rectifier are: (A) an auto-transformer; (B) a regulating reactance coil; (C) a tilting mechanism; (D) a relay; (E) a dial switch; (F) a switch or other means for connecting the auto-transformer directly to the arc, and, (G) a bulb and its holder.

The reactance coil is for the purpose of steadying the arc, and limiting the current when the carbons are brought together when striking an arc, which is a dead short circuit, to a value which will not be injurious to the bulb.

Modern rectifiers are so equipped that in case the bulb gives out the projectionist can switch over to the auto-transformer and continue the show with alternating current, using the auto-transformer as an economizer. Also modern rectifiers are equipped with a dial switch by means of which the projectionist may instantly vary the amperage, within the minimum and maximum capacity of the bulb.

INSTALLATION.—Rectifiers are ordinarily received in two separate shipments, one of which, the rectifier itself, weighing several hundred pounds, will probably come by freight. The other, the glass bulb, carefully packed in a specially made case, is usually sent by express. In removing the bulb from its crate proceed strictly according to directions in loosening the crate, after which carefully lift out the bulb. It will be in an inverted position. Turn it slowly over and carefully let the mercury run down into terminals B, C. In rolling, the mercury should make a sharp, cracking sound, which is an indication that the tube is in good condition.

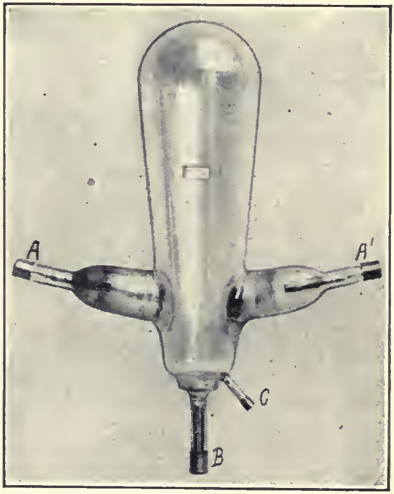


Figure 183.

The rectifier should not be located directly in the projection room, unless there be some means provided for covering the bulb so that its light will not shine in the room. Light in the projection room is highly objectionable. One very good method is to install the rectifier in an adjoining room and cut a space through the wall just large enough to admit the front panel of the rectifier. This allows the projectionist to have access to the switches for the purpose of varying the amperage, or changing over to A. C., and at the same time excluding the light from the room. Another way is to paint the bulb black, using lampblack ground in oil, thinned with turpentine. This does not in any way injure the bulb. It is in fact good for it as it will radiate the heat better.

There is but little sound from a rectifier except a humming sound which comes from the transformer. Care should be exercised that there is no sheet metal near the machine. If there is the magnetic action of the transformer will probably set up vibration therein, which will cause more or less objectionable noise.

VENTILATION.—There must be ample ventilation where the rectifier is located. Lack of ventilation will operate to greatly shorten the life of tubes.

CAUTION.—Tubes should never, under any circumstances, be operated above their maximum capacity.

COMPARATIVE RESULTS.—Experiments by Simon Henry Gage and Henry Phelph Gage, Cornell University, have shown that the losses through the pulsation of the current with the mercury arc rectifier are very slight. A mercury arc rectifier using 40 amperes at 52 volts gave 12-150 C. P., whereas straight D. C., 40 amperes at 51 volts, with the same carbon set, only gave 12,350 C. P., a difference of about 200 C. P.

On page 533 you will find a chart indicating the various troubles one is likely to encounter when operating a rectifier, together with the most probable cause or causes of each. We recommend a careful study of this diagram. With this chart and the detailed instructions contained in this book, plus a fair supply of common sense, I believe any projectionist ought to handle a rectifier without serious difficulty.

GENERAL ELECTRIC MERCURY ARC RECTIFIER.—The General Electric Company, Schenectady, N. Y., manufactures rectifiers for use on projection circuits in two capacities, viz.: 30 and 50 amperes.

Fig. 190 illustrates the design of the G. E. rectifier furnished for the first time in 1910. Several hundreds of these older rectifiers are still in service, and in response to many requests we are giving instructions on them. Cuts of the old rectifier are shown in Fig. 190. Diagram of connections is shown in Fig. 191.

The General Electric rectifiers may all be used on either 110 or 220 volts. They are made for all commercial cycles from 50 to 133, and for 25 to 40 cycle circuits. The late type G. E. rectifier is shown in Fig. 184. On the front of the panel are mounted the fuses, a three-pole, double-throw switch, the adapting links, the dial switch, and either an ammeter and voltmeter, or either one singly, these instru-

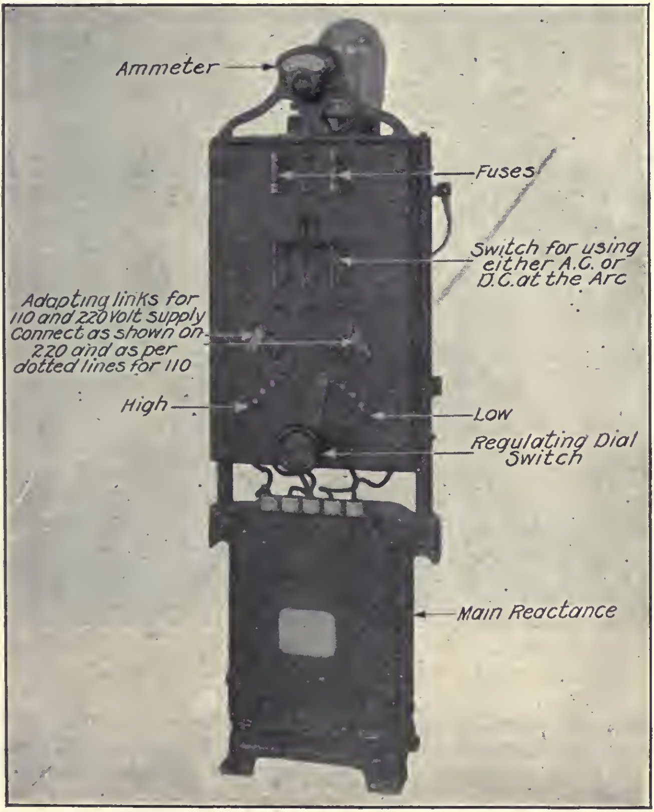


Figure 184.

ments only being provided when especially ordered. On the back of the board, or panel, are mounted the regulating reactance, the various relays, current limiting resistances, tube, etc., as in Fig. 185.

The machine is not excessive in weight, occupies but little floor space, and is entirely automatic in its operation. To

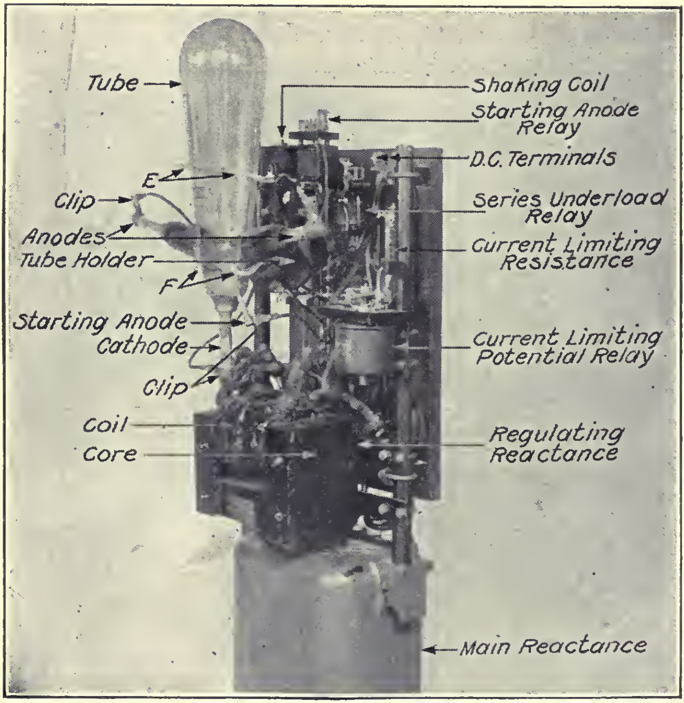


Figure 185.

start the rectifier, all that is necessary is to close the A. C. supply and projector table switches, and bring the carbons of the lamp together. The rectifier will then automatically start.

VOLT AND AMMETER.—The volt and ammeter (when ordered) are of the D'arsonval, or permanent magnet type.

They are accurate and are connected in the secondary, or D. C. side, hence show the voltage and amperage at the arc. **They should always be ordered when a rectifier is purchased.** The better practice is that they be mounted on the wall in front of the projectionist, rather than on the rectifier, which

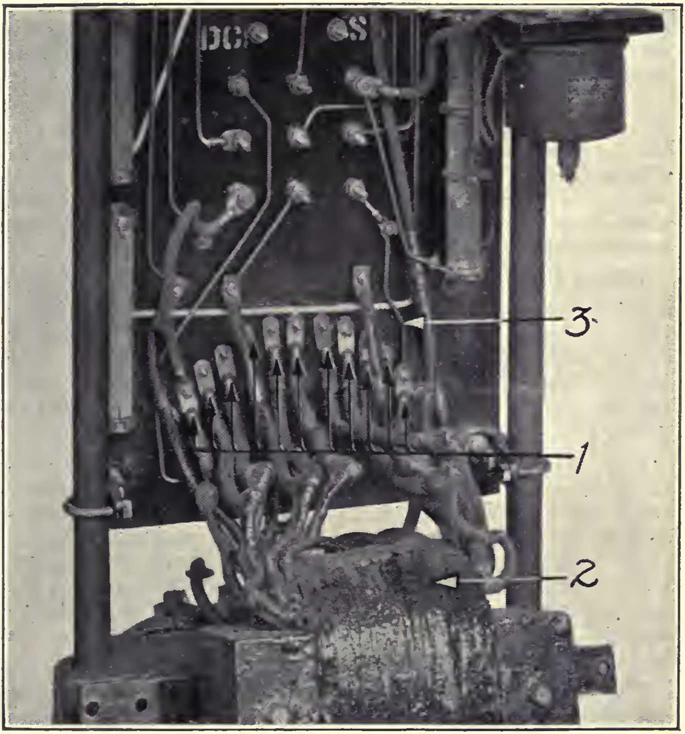


Figure 186.
General Electric Mercury Arc Rectifier

latter, probably, will not be placed directly under the projectionist's eye. These instruments may be removed from the rectifier and so mounted if desired.

FUSES.—Fuses of greater capacity than those furnished with the rectifier should never be used. For a 30 ampere rectifier use 35 ampere fuses; for 40 or 50 ampere machine use 55 ampere fuses.

FROM DIRECT CURRENT TO ALTERNATING CURRENT.—In Fig. 184 we see a triple-pole, double throw switch in the center of the panel. By throwing this switch over the tube is cut out and A. C. direct from the lines is supplied to the arc, using the main reactance as an economizer. This is for use in case of accident to the tube. The switch as shown in Fig. 184 is set for D. C.

If the switch is thrown over to A. C. it may be found there is not sufficient amperage, in which case lead 3, Fig. 186, may be moved along studs 1, until sufficient current is obtained. Do not use more than 60 amperes, A. C. **The rectifier is built primarily for changing A. C. to D. C., and, while its main reactance may be used as an economizer, that provision is designed for emergency only.**

CONNECTING OR ADAPTING LINKS.—The connecting or adapting links, Fig. 184, enable the rectifier to use either 110 or 220 volt supply. To change from one to the other it is only necessary to change the connection of the links. For 220 volt supply they should be connected to the two upper and the two outer lower studs; for 110 volt supply connect to the two upper and the two inside lower studs.

THE DIAL SWITCH.—The dial switch has eleven contacts which are connected to eleven taps on the regulating reactance, Figs. 185 and 186. This connection may be examined in Fig. 186, in which the regulating reactance, 2, has been dropped down to show the connections. This switch enables the projectionist to regulate the amperage at the arc, and any amperage within the capacity of the rectifier may be instantly had by merely moving the switch to the left to raise, or to the right to lower, as per Fig. 184.

THE MAIN REACTANCE, Fig. 184, is nothing more nor less than an auto-transformer. It has three distinct functions, viz.: (a) It adjusts the voltage of the alternating current to the pressure necessary to secure the proper D. C. amperage at the lamp; (b) it supplies a neutral point between the alternating current lines and forms the negative of the direct current lines; (c) by its reactance it keeps the rectifier tube in operation while the current passes through the zero point of the alternating current wave.

THE REGULATING REACTANCE.—The regulating reactance, Figs. 185 and 186, is nothing more nor less than a choke coil, with eleven or more taps taken off at certain points along the winding. These taps are connected to an equal number of contacts of the dial switch, Fig. 184, so that the alternating current can be choked back or reduced to a value just sufficient to give the desired amperage at the arc.

Fig. 187 is a diagram of the connections of the General Electric mercury arc rectifier; all parts of the rectifier are shown diagrammatically **without reference to their actual**

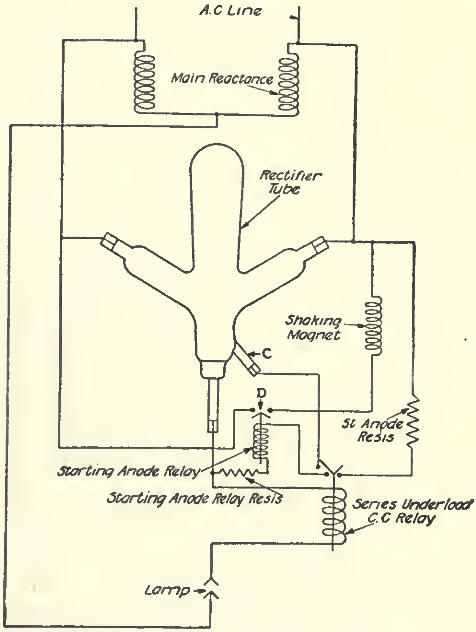


Figure 187.

position with relation to one another when mounted on the rectifier, the idea being merely to illustrate the method employed in starting. It will be seen that three coils are used for starting, viz.: A shaking magnet, a series underload relay and a starting anode relay, the latter, which is normally open, but picks up when the carbons of the lamp are brought together, thus closing the shaking magnet circuit (see D, Fig. 187), whereupon the shaking magnet pulls the tube over to one side, or, in other words, "rocks" it, thus allowing the mercury in cathode B, Fig. 183, to bridge over and form a connection with the mercury in starting anode C, which shunts the current from the starting anode relay D, Fig. 187, circuit, and operates to demagnetize its coil, thus allowing its plunger to fall and open the shaking magnet circuit, whereupon the tube, by its own weight, rocks back into vertical position, thus breaking the mercury bridge between anode C and cathode B. After the tube has started operating, and the arc has been struck, the series underload relay which is connected in the D. C. circuit picks up, thus cutting the starting anode relay and shaking magnet entirely out of circuit. If the tube does not start at once the shaking magnet will continue to rock the tube until it does.

INSTALLATION.—After the rectifier set has been uncrated and placed in its operating location (see "Installation," page 517), the tube should be placed in the holders E, F, as per Fig. 185. This is accomplished by pressing the narrow part of the tube, just above anode arms A, A1, Fig. 183, into upper clip E, Fig. 185, carefully lowering the tube until anodes A, A1, Fig. 183, rest on the lower clips, F, Fig. 185. Having the tube in place, you will find four wires covered with a sort of glass bead insulation, these wires terminating in brass spring clips, Fig. 188. Connect the two upper ones (either one to either anode) to anodes A, A1, the small lower one to starting anode C, Fig. 183, and the large lower one to cathode B, Fig. 183, as shown in Fig. 185. Next connect the A. C. supply lines to the two terminals, marked A-C, at the upper left-hand corner of the panel—that is to say, the left-hand corner as you stand facing the tube on the back side of the machine. Next connect the positive D. C. terminal, Fig. 185, marked + to one side of the projector table switch, and through the projector table switch to the upper carbon arm of the lamp, and connect the negative (marked) D. C. terminal to the other side of the projector table switch, and through it to the lower carbon arm of the lamp. Connect the adapting links in the front of the panel according to the voltage of your alternating current supply, as already directed. Having accomplished all this, with the triple-pole **switch closed in the upper position,** as per Fig. 184, and with the A. C. supply and D. C. projector table switch closed, the rectifier is ready to start.

OPERATION.—To start the rectifier bring the lamp carbons together, the tube will rock, and will either start or continue rocking. As soon as it starts, slowly separate the carbons to the usual distance for a D. C. arc. When the

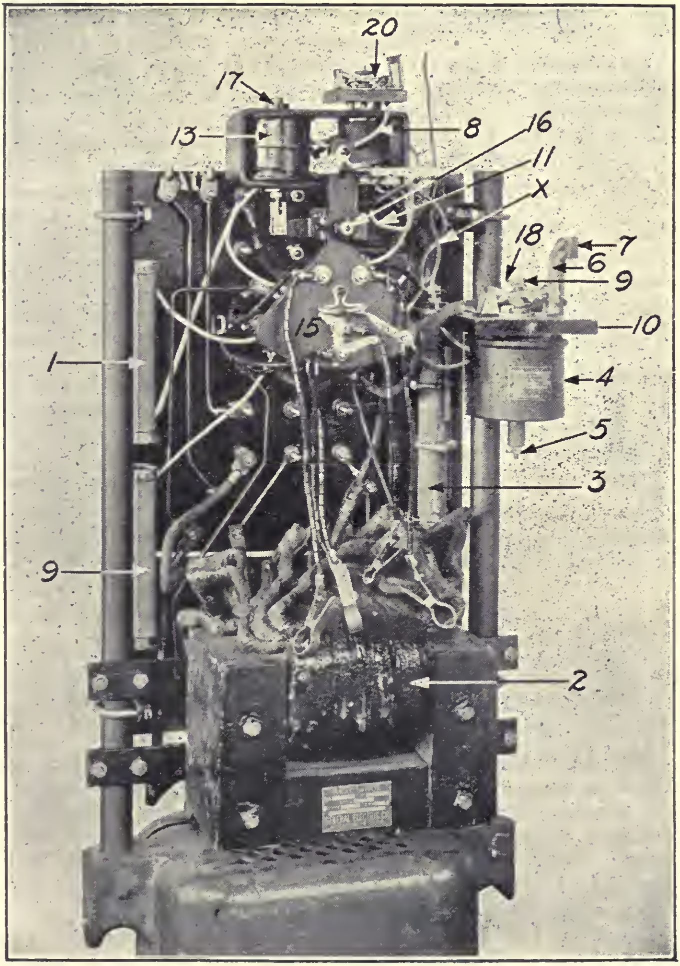


Figure 188.

carbons have been separated so that the voltage between them is about 45, the potential relay 4, Fig. 188 (if it is a 40 or 50 ampere rectifier; there is none on the smaller size) will operate and short-circuit current limiting resistance 3, Fig. 188, thus increasing the arc current to whatever value the dial switch is set for.

CAUTION.—When you first begin to use a rectifier be sure that the potential relay operates. If it does not, current limiting resistance, 3, Fig. 188, will heat, and while it would be difficult to actually burn it out, damage might be done to it or to the insulation of surrounding wires.

The projectionist can tell when this relay acts, as follows: When the carbons are first separated the current will be comparatively weak, but when the relay acts there will be a sudden increase in brilliancy at the spot. The knack of detecting the acting of the relay can be acquired by starting the arc several times and slowly separating the carbons until the relay picks up, having a man at the rectifier to tell you when it does pick up in case the rectifier is at a distance.

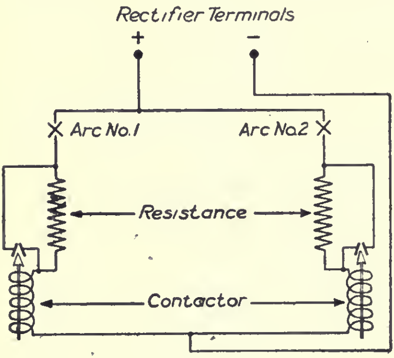


Figure 189.

To stop the rectifier, open the projector table switch, though opening either the switch on the A. C. lines or the triple-pole switch in the face of the rectifier panel will have the same result.

OPERATING TWO ARCS FROM ONE RECTIFIER.—When it is desirable to operate two arcs from one rectifier the General Electric Company will furnish two resistances equipped with contactors, one to be used in series with each lamp. These resistances consist of a number of coils, inclosed in a ventilated sheet metal box, for mounting on the frame or standing on the floor beside the machine.

Diagram, Fig. 189, shows the resistance connected in the lamp circuits. The operation of dissolving one reel into another is briefly as follows: Assume the projectionist to be running a picture on projector No. 1, in which case the contactor is closed by hand (thus cutting out the resistance which is normally in circuit) at the start and is then held closed by a magnet coil. At any time while this reel is running the projectionist (leaving the contactor on arc No. 2 open) may start projector No. 2, at about 10 amperes, thus allowing the carbon to be warmed up on No. 2 while the reel is still being run on projector No. 1. At the end of the reel on projector No. 1, projector No. 2, with arc burning with resistance in circuit, is then started, and the contactor closed, thus cutting out the resistance and boosting the current to normal, at the same time short-circuiting the arc of projector No. 1 and putting it out, which stops the current flow in resistance box No. 1, thus opening the contactor. The resistance cannot be accidentally left out when the second arc is struck. When the first arc is short-circuited the contactor opens, which automatically cuts in the resistance. These resistances prevent overloading the rectifier. Remember that the resistance is in when the contactor is open.

We would most emphatically recommend to exhibitors the purchase of the large rectifier. Modern practice is to use high amperage and project a brilliant picture. The first cost will be greater, but it is well worth the money. This holds good even for the small towns, provided sufficient current is available to supply the large rectifier.

PRACTICAL OPERATION.—You need not be afraid to perform any of the various operations we shall describe in case of necessity. Just follow the directions and use a little common sense, remembering where each part goes, or, better still, attaching a labeled tag to it as you remove it.

There is no mystery about these things. All too often the projectionist hesitates to attempt the making of repairs through fear of being unable to get the thing back into shape. The rectifier is strongly made; its parts are very simple. We repeat: Follow the instructions here given, supplementing them by ordinary common sense, and you will not be likely to have any trouble.

Current-limiting resistance 3, Fig. 188, consists of a strip of resistance metal, wound in spiral form, covered with insulating material and supplied with contacts at either end. Resistances 1 and 9, Fig. 188, are of wire wound on asbestos, the whole dipped in an insulating material.

The purpose of current-limiting resistance 3, Fig. 188, is as follows: When the lamp carbons are brought together the effect is, to all intents and purposes, to form a short circuit, which would have the effect of sending a heavy rush of current through the arc circuit. **Resistance 3, Fig. 188, takes the place of the resistance the arc will offer after the carbons are separated.** This resistance is automatically cut into circuit when the plunger of relay 4, Fig. 188, is down; or, in other words, when relay 4 is "open." When the carbons are opened and the arc struck, the effect is to add the resistance of the arc to the resistance offered by current-limiting resistance, 3, and thus raise the voltage of the lamp circuit. When this voltage reaches a certain point (about 40

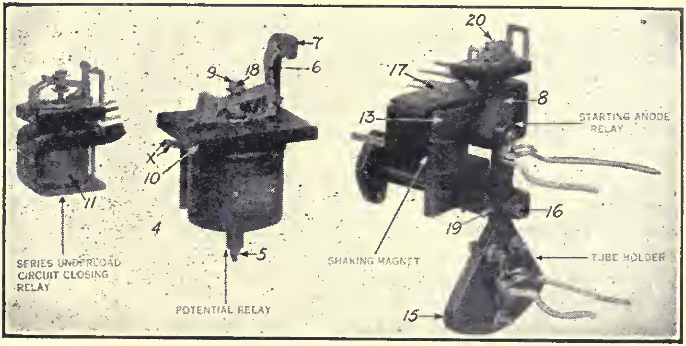


Figure 189a.

volts) the energy of the magnet of relay 4 becomes sufficient to raise plunger 5, Figs. 188 and 189, and bring blade 6, Figs. 188 and 189, into contact with block 7, Figs. 188 and 189, thus short-circuiting current-limiting resistance 3, and raising the D. C. amperage.

Should relay 4 at any time fail to act, it is likely plunger 5, Figs. 188 and 189, is stuck, which might be caused by a grain of sand, a bit of dirt or from some other cause. This plunger may be removed from the magnet by pulling out split key 18, Figs. 188 and 189, and, while holding stationary nut 9 at the top of the plunger, unscrew plunger 5 by turning its lower end. Having removed the plunger and ascertained the cause of its sticking it may be replaced, and when you are able to get split key 18 into its hole the plunger is in the proper location. **In replacing nut be sure to get it**

right side up. If you cannot get the split key in, the probability is that you have the nut wrong side up. Also, **in replacing nut 9, be sure to get the two washers underneath it in place.**

It will be well to clean the contact between block 7 and blade 6, Fig. 189, about once a month, using 00 emery cloth.

Should anything occur to seriously injure the parts on top of relay 4, Fig. 189, as for instance something falling on them and smashing the whole thing so badly that it could not readily be put back into shape, then new parts can be obtained from the factory. In order to remove the old parts, take out three screws in the top of block 10, Fig. 189, the same being countersunk into the block, two on one side of the brass parts and one on the other; disconnect the wires from the parts; take out plunger 5, as per former directions. You can then lift the block off and replace it with a new one. The block should be ordered complete, with the parts assembled. Should it ever become necessary to remove the coil of relay 4, Fig. 189, first proceed, as before directed, to remove block 10, Fig. 189, whereupon you will see three screws in the top of the coil casing. Remove them, disconnect the two wires which lead from the coil, and disconnect wires (two of them) X, Fig. 189. You may then lift the coil out, and replace it with a new one if necessary.

The instructions given for removing the top and the coil of relay 4, Fig. 189, apply equally to all the other relays; just remove the screws in the top of the block (the screws are, in all cases, countersunk), disconnect the wires, remove the relay plunger, and the whole thing comes off.

Resistance coil 9, Fig. 188, is connected in series with the contacts of series underload relay 11, Figs. 188 and 189. (You cannot see this relay in Fig. 188. It is under arrow head 11). This resistance is **not** in series with the relay coil, but serves to limit the flow of current through the starting anode, Fig. 185. But for this resistance the flow of current through the starting anode would be so heavy that there would be liability of damage to the tube.

Resistance coil 1 and 9, Fig. 188 may be removed simply by pulling them out of their clips as you would a cartridge fuse. Resistance coil 3 may be removed by disconnecting the wires attached to it, and taking out the screw which holds the carrying clip to the panel.

SHAKING MAGNET.—The action of the rectifier is made automatic by means of shaking magnet 13 and relay 8, Figs.

188 and 189. These magnets are therefore very important. Part 15, Figs. 188 and 189, is so made that it brings the tube back to the vertical position after it has been rocked by the action of the shaking magnet, through force of gravity. Should the tube at any time fail to rock to the vertical position, it is most likely due to friction in spindle 16, Figs. 188 and 189. This friction may be overcome by means of a drop or two of oil on the bearing surfaces, just behind the nut on the end of the bolt, and at the back of the spindle. It is also possible that dirt may work in beside plunger 17, Figs. 188 and 189. This plunger may be removed by taking out the bolt in the fork at its lower end, and driving out the small pin in nut 17 at the top of the plunger. The plunger can then be dropped down enough to clean it.

Should plunger 20 of relay 8, Figs. 188 and 189, fail to work, it may be taken out and examined by removing the split key at its upper end and pulling the plunger out at the bottom.

Should the rectifier at any time fail to act, the very first thing to examine and test will be your fuses, including those on the front of the panel. Don't try anything else until you have **tested** the fuses. **It is quite possible you may get a spark at the carbons of the lamp when one of the fuses is burned out.**

ORDERING RENEWAL PARTS.—Almost every projectionist will, sooner or later, find it necessary to replace certain parts of the rectifier equipment that wear out from usage.

IMPORTANT.—To insure correct filling of orders for such parts it is essential that the following information be given with each order:

1. Catalog number and

2. Serial number of complete rectifier equipment. (These will be found stamped upon name-plate attached to front of rectifier panel.)

3. Catalog number, specification or any distinguishing mark that may appear on the part wanted.

3A. If no marking can be found, describe the part as clearly as possible. An accurate pencil sketch of the part helps, too.

4. Quantity of each part wanted.

The order should then be forwarded to the nearest sales office of the General Electric Company, or direct to its General Offices at Schenectady, N. Y.

OLD STYLE MERCURY ARC RECTIFIER.—The following information is prepared for the convenience of projectionists using G. E. Rectifiers of the design furnished prior to 1918, many of which are still in use, particularly in the west.

Before putting this information to use it is well to compare your panel with illustrations shown in Fig. 190 and to determine whether they correspond.

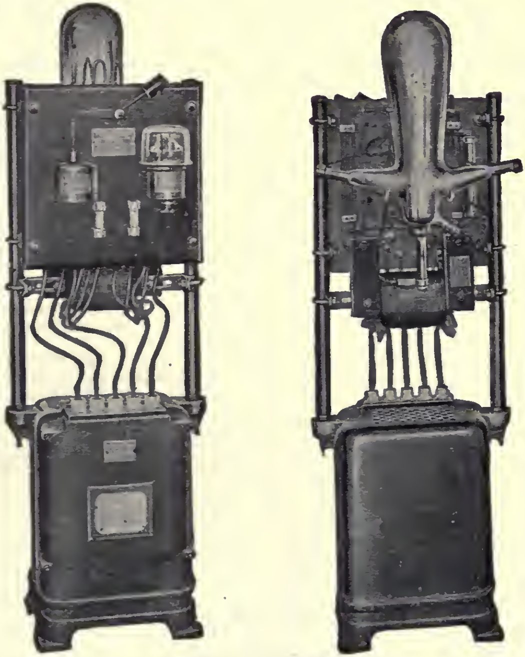


Figure 190.

1. The leads marked "AC" should be connected to the lower studs of a double-pole switch located near the motion picture projector. The upper studs of the switch should be connected to the "AC" source of supply.

2. The leads marked + and — should be connected respectively to the positive (upper) and negative (lower) carbons of the motion picture lamp.

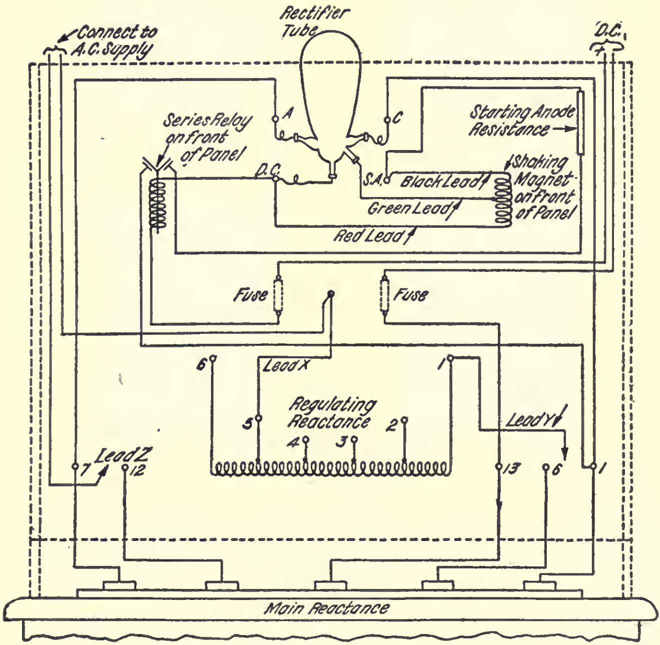
3. If the "AC" supply voltage is 110, then connect the

flexible lead marked "Z" to stud marked 12, and flexible lead marked "Y" to stud marked 6 on main reactance.

If the "AC" supply voltage is 220 volts then connect lead "Z" to stud 7, and lead "Y" to stud 1 on main reactance. Note: do not disturb the other connections that are made on studs 1, 6, 7 and 12 of the main reactance, but only place leads "Y" and "Z" as directed.

4. The tube holder should be reversed so that the clip and support will be turned away from the panel instead of towards the panel, as it is when shipped.

WIRING DIAGRAM FOR OLD STYLE RECTIFIERS.— 5. Remove the tube from its box, being very careful not to handle it roughly, nor to strain the seals in any way whatever. Care must also be taken to prevent the mercury from suddenly flowing into any of the arms, otherwise the



Back View of Rectifier Panel Showing Wiring

Figure 191.

RECTIFIER TROUBLE CHART.

TUBE DOES NOT START. See if there is voltage and if it is up to normal.

- **TUBE DOES NOT TILT.**
  - No current at tube terminals.
    - Current at switch—Fuses blown.
    - No current at switch—Line voltage off.
  - Relay contact not closed.
    - Friction or bent stud.
    - Relay contact is poor.
    - Tilting circuit open.
    - Secondary coil of magnet short circuited.
- **TUBE TILTS.**
  - Amalgam bridge between electrodes—Install new tube.
  - D. C. circuit open.
    - Lamp circuit open.
    - Carbons not making good contact with each other or with the lamp jaws.

TUBE TILTS

- Does not return to vertical.
  - Lead on starting anode broken or loose.
  - Mercury pools do not make contact.
  - Friction in tube holder.
    - Adjust tube; it does not tilt far enough.
- Returns to vertical without flash after repeated tilts.
  - Tube is defective.
  - Tube has lost its vacuum.
    - New tube.
- Flashes and goes out.
  - Lead to positive electrode anode loose or broken.

Tube continues to tilt after starting.
- Relay does not open the circuit.
  - Winding short-circuited, friction or bent stud.

Tube goes out.
- Lamp carbons separated too far.

Tube tilts feebly.
- Voltage of circuit low.
- Frequency of current not right.
- Friction in tilting mechanism.
- Tube is too heavy at bottom.

Outfit is noisy.
- Reactance coil loose on frame.
- Reactance coil air gap not wedged tight.
- Cover vibrates.
- Operating room floor vibrates—set outfit on felt pads.

Arc is noisy.
- Carbons too hard—use softer ones.

NOTE—When proper vacuum exists the mercury gives off a sharp clicking sound when it is run from one end of the tube to the other. Absence of this sound and the presence of air bubbles show loss of vacuum.

Tube may be defective by short-circuiting between starting anode and cathode. When in this condition it is badly blackened.

resultant pound might damage them. Examine the tube for vacuum by noting the sound the mercury makes when allowed to roll gently about in the large chamber. If it makes a clear, metallic, click, the vacuum is good, but if the sound be dull and the mercury sluggish in moving, the vacuum is either partially or wholly destroyed. If the vacuum is poor, the life of the tube may be short, or it may not start at all.

To insure careful handling and safe delivery, Mercury Arc Rectifier tubes are always shipped by express in the special box as they come from the factory.

6. Place the tube in the holder by inserting the small part of the tube just above the anode arms in the upper clip, then gently lower it until it rests firmly on the lower support. Connect the tube and beaded leads according to diagram, Fig. 191.

7. Adjustment of current (number of amperes) at the arc is obtained by connecting lead marked "X" to studs 6, 5, 4, 3, 2 or 1 of the regulating reactance. Stud 1 gives the maximum and stud 6 the minimum number of amperes.

In starting up the first time it is best to start with lead "X" on stud 6 and move toward the maximum position by steps until the desired current is obtained, as indicated by ammeter. For this adjustment it is advisable to connect an ammeter in series with the arc of the projector.

8. With the above instructions carried out, all that is necessary to start is to close switch in the 'AC" line, and bring carbons of lamp together. The automatic shaking device should then rock the tube until the tube starts. As soon as tube starts separate carbons.

9. The best and whitest light can be obtained when ⅝ in. cored carbon is used above and ½ in. solid carbon below, being careful not to get solid carbons too hard.

WESTINGHOUSE MERCURY ARC RECTIFIER.—In Plate 1 we get a view of the front of the Westinghouse Mercury Arc Rectifier designed for use on projection circuits. It is built in 30, 40 and 50 ampere sizes, the general design, characteristics and appearance being the same for all.

Each outfit consists of a cast iron main frame on which is mounted an auto-transformer, L-L, Plate 3; reactance coil, Q, Plate 3; a tilting mechanism, B, D, K, P, Plate 2; a relay, I, Plate 3; a five-point dial switch, Plate 1, and E, F, G, H, I, Plate 2; adapting links, Plate 1; a tube and tube holder, 24, 25, 26, Plate 4, all inclosed in a perforated sheet steel cover. The machine occupies but little floor space.

In Plate 2, we have a view of the rectifier with the perforated sheet steel cover, the cover of the dial switch and the tube removed. At the bottom, in the corner, is the tilting magnet, P, the operation of which is very clearly shown. When magnet P is energized, its plunger, K, moves downward and tilts or rocks the tube. The construction of the dial switch is also very clearly shown, the round buttons, E, being dummies, over which switch contact fingers G slide

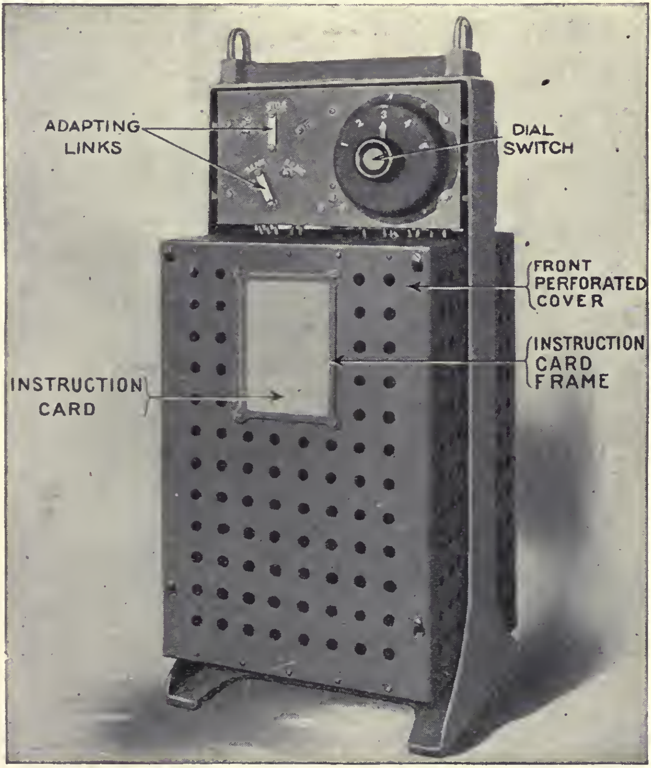


Plate 1, Figure 192.

from one wide contact, F, to another. At the bottom are four wires, L, M, N, O, coiled up and terminating in brass spring clips. These are the leads which connect to the anodes and cathodes of the tube, as per 9-9-12-29, Plate 4.

In Plate 3 we have a rear view of the outfit, showing, near the bottom, the reactance Q, and above it the auto-transformer L-L. In Plate 3 we see at the left the D. C. leads,

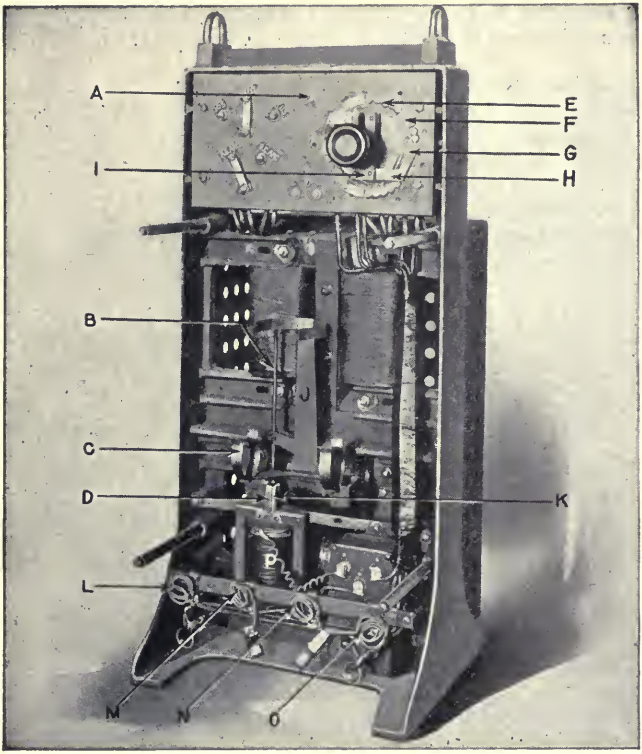


Plate 2, Figure 193.

A, mounting screws for relay; B, upper bulb spring holder; C, lower bulb spring holder; D, brass guide for tilting rod; E, dummy contacts; F, contacts; G, contact finger; H, contact arm; I, insulating support for contact; J, bulb holder casting; K, tilting magnet plunger; L, M, N, O, wires having spring contacts at end to connect to tube anodes and cathodes.

A, B, which connect to the arc lamp circuit, the inside one, A, being the negative and the outside or left hand one B, the positive. The positive must, of course, connect through the projector table switch to the top carbon arm of the lamp, and the negative through the projector table switch to the bottom carbon arm of the lamp. The A. C. leads, H, are seen in Plate 3 at right hand side. These leads connect directly, through a switch and fuse, to the alternating current supply. In the center, at the top of Plate 3, is relay magnet 1, the purpose of which will be explained further on.

THE AUTO-TRANSFORMER, L-L, Plate 3, consists of an iron core with a winding of heavy copper wire. It is similar to an ordinary transformer, except that its connections are such that in effect it has only one winding, whereas the ordinary transformer has two, viz.: a primary and secondary. Its function is to change the voltage of the A. C. supply circuit to the pressure required at the arc. The center point of the winding also forms the negative terminal of the arc circuit, as per 3, 4, 4, in diagram, Plate 5. See Fig. 199, page 546.

REACTANCE COIL.—The reactance coil, Q, Plate 3, is similar in appearance and construction to a transformer. It is connected into the alternating current circuit for the purpose of limiting current flow when the carbons are brought together to strike the arc, to a value that will not be injurious to the tube; also it operates to insure steadiness of the arc and to prevent any wide fluctuations of the current when the length of the arc is changed. The general effect is to make the arc much easier to handle.

TILTING MECHANISM.—Each rectifier is provided with an automatic tilting device, consisting of parts B, D, K and P, Plate 2. This device is so connected that the closing of the carbons energizes magnet P and thus causes the tube to tilt, which makes the rectifier a self-starter. The mechanism is operated by magnet P, Plate 2, the pull of which is applied to the tube by coil spring B, Plate 2, as shown. A spring is used instead of a rod in order to prevent the tube from being subjected to unnecessary and violent shock.

THE RELAY, 1, Plate 3, is another magnet, used to operate the contacts which open the tilting magnet circuit when the arc is started, thus preventing the tube from tilting at any other time. But for this cutout the tilting magnet would continue to operate, and the tube would be tilted, or rocked continuously.

THE FIVE POINT DIAL SWITCH, Plates 1 and 2, is used to change the connections to the reactance coil in such way as to vary the arc current to any desired value within the limits of the machine. This switch, as its name indicates,

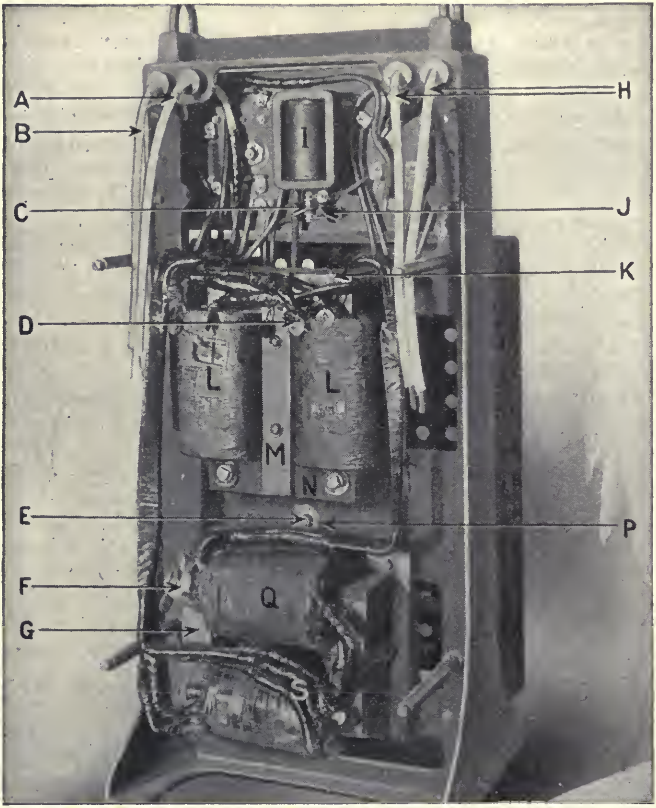


Plate 3, Figure 194.

A, positive D. C. lead; B, negative D. C. lead; C, relay contact disc; D, transformer lead tags; E, rear end of bulb holder shaft in ball bearing; F, reactance lead tags; G, fibre clamping blocks for reactance coil; H, A. C. leads; I, relay magnet; J, relay contact stud; K, transformer iron; L, transformer coil; M, clamping block for transformer iron; N, mounting bolt for transformer; P, cotter pin; Q, reactance coil; R, reactance iron; S, reactance coil leads.

gives five different values of current, and the change may be made from one point to another without breaking the arc.

THE UPPER ADAPTING LINK, 17, Plate 4, is for the purpose of changing the connections to the reactance coil, so as to provide proper voltage adjustment at the arc for different supply circuit voltages. In other words, the A. C. supply may be 220 or 110 on the face of it, whereas the actual pressure in the theatre, owing to drop in line, etc., may be anywhere between 210 and 230, or 105 and 115 volts. By means of this link it is possible to provide for these variations and make a connection suited to the actual voltage, which easily may be determined by using an A. C. voltmeter. If a voltmeter is not available the lighting company should be requested to make the test.

THE LOWER LINK CONNECTOR, 18, Plate 4, is used in emergency, to transfer the arc from the tube circuit to direct operation on the alternating current circuit, in case the tube should fail or something else happen to the rectifying side of the machine. For direct current operation (rectification) this link should be placed so as to join the lower of the three terminals and the upper right hand terminals, marked "D. C. Arc"; for alternating current operation the link should join the lower terminal and the upper left hand terminal marked "A. C. Arc." Be sure that the wing nuts are well tightened so as to clamp the links firmly.

THE TUBE is a glass vessel into which a small amount of mercury has been placed, and from which all the air has been removed, causing a vacuum. The general characteristics of its operation have been described under "General Remarks," page 515. It has four terminals, the upper ones being the graphite anodes, the smaller, lower one the starting anode and the larger lower one the cathode; both the two lower are of mercury. These various terminals are connected to coiled leads L, M, N, O, Plate 2, by means of brass spring clips, as at 9, 9, 12, 29, Plate 4.

INSTALLATION.—The rectifier will be received in two shipments. The glass tube, carefully packed in a special crate, is usually sent by express, whereas the remainder of the outfit, being the completely assembled rectifier (except the tube) all ready for operation, will probably be sent by freight. When the outfit is received, remove it from its case and place in the location selected. Remove the perforated sheet steel cover and connect the A. C. feed wires to rectifier leads H, Plate 3, through a line switch and fuses,

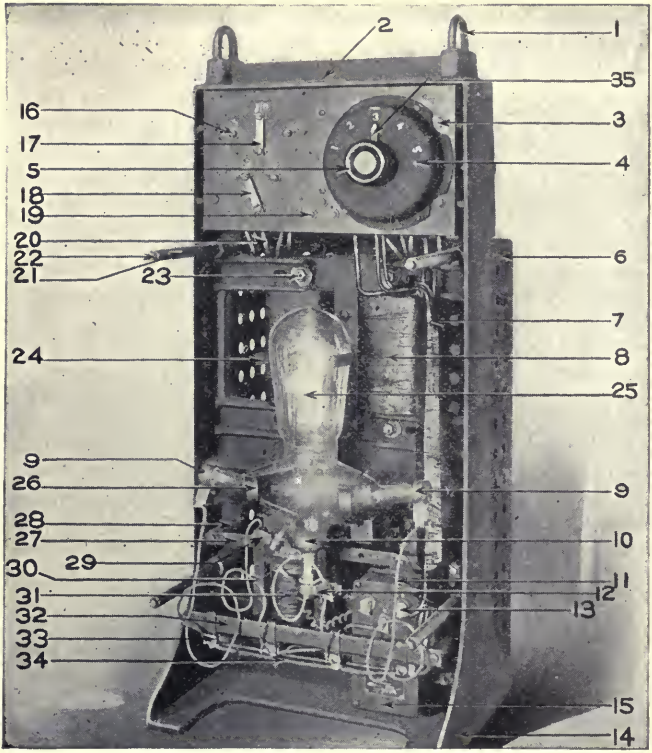


Plate 4, Figure 195.

1, lifting lug; 2, name plate; 3, mounting bolt for slate panel; 4, cast iron cover for dial switch; 5, dial switch handle; 6, rear perforated cover; 7, cable containing leads; 8, transformer; 9, spring clip on side terminal of bulb; 10, mercury pool in bulb; 11, lead to side terminal of bulb; 12, spring clip on large lower terminal of bulb; 13, resistance box terminal; 14, main cast iron frame; 15, resistance box; 16, stud for link connector; 17, upper link connector; 18, lower link connector; 19, end of relay contact stud; 20, transformer leads; 21, stud for front perforated cover; 22, bolt for front perforated cover; 23, mounting bolt for transformer; 24, upper bulb holder spring; 25, bulb; 26, lower bulb holder spring; 27, mounting strap for tilting magnet and resistance box; 28, lug for tilting magnet and resistance box; 29, spring clip on small lower terminal of bulb; 30, tilting magnet frame; 31, tilting magnet coil; 32, terminal board; 33, connector on terminal board; 34, wiring from terminal board; 35, dial switch pointer.

as per instructions mounted on front cover of the rectifier. Connect leads D — and C + to the projector table switch with the positive (+), B, Plate 3, connected to the top carbon arm and the negative (—), A, Plate 3, connected to the lower carbon arm. Open the crate containing the tube by removing two screws from the center of each side. Lift the outer portion of the crate away, which will leave the tube suspended from the inner portion of the crate. Loosen the line tape and lift the tube carefully from the holder. Turn the tube upside down, slowly and very carefully, making sure that the mercury runs slowly into the two bottom terminals. The mercury in a tube that is in good condition should make a sharp metallic click when passing from one end of the tube to the other. Grasp the tube firmly in both hands, the right at the extreme top and the left grasping the mercury terminals, and, guarding carefully against collision, slide the tube into the lower spring clips of the tube holder, taking care that the springs do not cause the tube to slide into the tube holder with a jar.

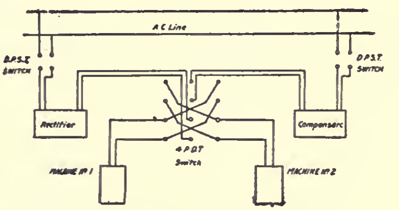


Figure 195a.

Be very careful not to allow the smaller mercury terminal to strike the tube holder, or any other object, as it is quite easily broken. After the lower part of the tube is properly placed, push the top part gently back into the upper spring. If it becomes necessary to remove the tube, as in case of changing location of outfit, the same method of handling should be followed. Connect the tube leads (that is, the flexible wires attached to the terminal board below the tube marked L, M, N, and O, Plate 2) to the tube, as shown at 9, 9, 12, 29, Plate 4. The wires may easily be traced in Plate 4. Connect wire 4, Plate 2, to the upper left hand tube terminal, 9, Plate 4; the lead M to the small lower tube terminal, 29, Plate 4; lead N to the large lower terminal, 12, Plate 4, and lead 0, the last one, to the right hand upper terminal, 9, Plate 4. The upper link connector on the slate panel at the top of the outfit should now be connected to suit the voltage of the supply wires, which should be determined by actual test with a reliable voltmeter. It may be noted in this connection that the voltage for which the link is set should be tested when the rectifier is in actual operation, since the voltage of the line may decrease with the added load. It is unlikely that once this connection is properly made it ever will be necessary to change it. The outfit, without any further adjustment, is now ready for operation.

Plate 5 shows the wiring diagram for the three types of the Westinghouse rectifier. These diagrams are, we believe, of questionable value to the average projectionist. However, there are a goodly number who will be able to make use of them. The upper one is for the 30 ampere, 110-220 volt, the center one for the 40 ampere, 110-220 volt, and the lower one for the 50 ampere, 110 volt rectifier.

OPERATION.—With fuses of proper capacity in place, close both the A. C. line switch and the projector table switch and bring the carbons together, whereupon the tube will rock, a spark appearing between the two mercury pools at each tilt until the arc starts, when the whole tube will light up and come to rest in a vertical position. The carbons should be instantly separated until the greatest amount of light is obtained on the screen.

Where the size of the theatre and equipment only justifies the purchase of a single rectifier, the problem of blending one reel into the next has been solved as described below: The only extra equipment necessary is a compensator or economy coil such is is usually found in a theatre using alternating current, and a four-pole, double throw switch.

The wiring is shown in Fig. 195a and requires no elaborate explanation. By means of this plan the change-over may be made without any very seriously objectionable indication of the fact on the screen. The projectionist, we will say, is showing the first reel of a feature film on machine No. 1, which is fed from the rectifier, the switch being thrown to the left. About one minute before the end of the reel is reached he throws the switch to the right, starting the arc on machine No. 2 through the rectifier, while projector 1 is transferred to the alternating current supply of the compensator, and the reel is completed in this manner. This gives the carbons on No. 2 time to burn to their proper brilliancy on D. C., ready to begin the second reel. The process is repeated toward the end of the second reel on projector 2. The procedure may, if desired, be reversed; that is to say, starting machine No. 2 on alternating current and later changing it to direct current. However, the first mentioned will be found more satisfactory, as it takes a short while for the direct current to burn the crater properly.

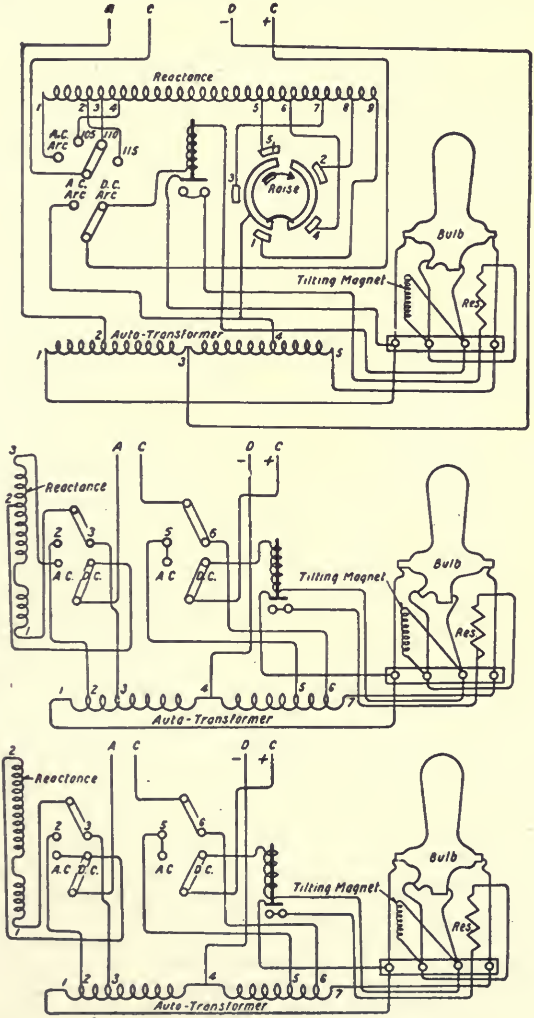


Plate 5, Figure 196.

The Transformer

THE transformer cannot be used on direct current. It is a device made entirely for use with A. C. Its purpose is to change alternating current of any given cycle (frequency) and voltage and amperage to an alternating current of the same cycle, but of different voltage and amperage.

The transformer assembly consists of four separate elements, viz.: a laminated core of iron, a primary coil, a secondary coil and a protecting casing or covering. In addition to this there may be other elements, such as an adjusting switch by means of which the amperage delivery of the secondary coil may be varied.

In Fig. 197 we have diagrammatic representation of the simplest form of transformer. The primary coil is wound around one "leg," or side of a laminated iron core, from which it is completely insulated. The secondary coil is wound around the other leg or side of the core, from which it also is completely insulated. In Fig. 197 it is only intended to convey a general idea of the relation of coils and core. In actual practice the coils are located as close together as they can be gotten. In some forms of construction one coil is inside the other.

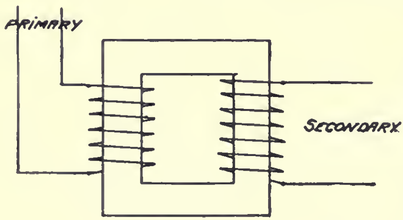


Figure 197.

ELECTRICAL ACTION.—The electrical action of a transformer is primarily based on the fact that if a wire be charged with alternating electro motive force it will be surrounded by a magnetic field, as illustrated in Fig. 198, in which A is a wire charged with A. C., B another wire having no mechanical connection with wire A, and the circles lines of magnetic force. Under the conditions shown, although wire B has no metallic connection with wire A, and is electrically insulated therefrom, an alternating current electro motive force will be induced or generated in wire B, and if wire A and B form complete circuits, current will flow in B.

A transformer depends for its action on this principle, supplemented by the following: When the switch is closed, charging the primary coil in Fig. 197 with alternating E. M. F., the wires thereof instantly become surrounded by lines of magnetic force, as shown in Fig. 198, and these lines of force acting on the iron core create a magnetic field of great intensity. This causes the primary coil to become in effect a choke coil of such power that unless current be taken from the secondary, and power be thus consumed, no wattage at all will be consumed in the primary coil. Electro motive force and current is generated in the secondary coil, which is immersed in the magnetic field created by the primary coil, because the magnetic field is in fact a magnetic circuit, its lines of magnetic force flowing in a fixed path through the air from the north pole to the south pole of the field.

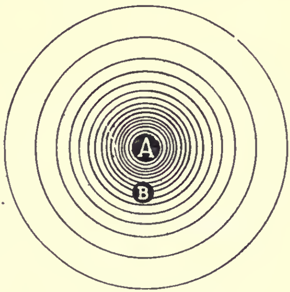


Figure 198.

Reverting back to "How Electricity Is Generated," Page 6, we find that electricity is generated in the armature of a dynamo because the wires cut across the lines of magnetic force which constitute the magnetic field. In a transformer the same identical thing is true in reverse. Current is generated in the secondary coil by reason of the fact that, instead of the wires themselves moving and cutting lines of force, the flow of magnetic energy "cuts" or passes across the wires, which amounts to exactly the same thing as the wires cutting through or across the lines of magnetic force, hence a current of electricity, called the secondary current, is generated or "induced" in the secondary coil. This secondary current is termed an "induced" current.

The action of a transformer is entirely automatic. The primary current creates a magnetic field which, as already explained, generates or "induces" a current in the secondary coil. This latter current also sets up a magnetic field, but its magnetic flow is in a direction opposite to the flow of the primary field. It therefore follows that when the secondary current flow is increased or decreased, the relative strength of the two magnetic fields (primary and secondary) is altered, whereupon the amount of current the primary coil takes from the lines is automatically increased or decreased until just sufficient is taken to maintain the balance between the magnetic fields. The action of a transformer, therefore, depends upon the balanced magnetizing action of its two coils.

Roughly the foregoing describes the electro-magnetic action of all transformers.

TWO TYPES.—There are two types of transformer, viz.: the straight transformer, in which there is no mechanical connection between the two coils, and the auto transformer, the wiring of which is illustrated in Fig. 199. The auto

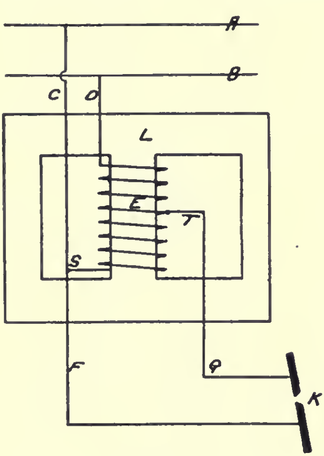


Figure 199.

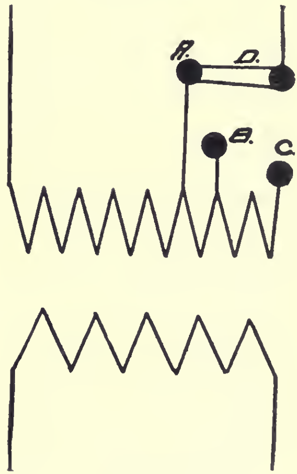


Figure 200.

transformer is an instrument having but one coil or winding, which serves for both the primary and the secondary coil, In Fig. 199, L is a laminated iron core on which the primary and secondary are wound in the form of one coil, or if you prefer it, two coils connected in series so that they practically form one coil. The primary wires are connected as shown, one to the terminal of the primary coil and the other to the terminal of the secondary coil at S. The secondary wires connect to one terminal of the secondary coil at T, and to the other terminal of the secondary coil at

S, as shown. The ratio of secondary voltage to primary voltage will depend upon the ratio of the number of turns in the primary as compared to the number of turns in the secondary, just as in the ordinary transformer.

If connection T were made in such way that the number of turns in the primary would be two-thirds the total number of coils in the primary and secondary combined, then the secondary voltage would be about one-third the primary voltage, and the secondary amperage will be about three times that taken from the supply lines. The auto transformer may be, and frequently is, so made that the secondary terminals may be, by means of proper switches, connected to points located anywhere along the length of practically the entire winding. There is at least one auto transformer which is designed for projection work. It is the product of a western coast manufacturer. It is reported as giving satisfaction.

EFFICIENCY.—Assuming a 100 per cent. efficiency, the watts consumed in the primary coil will equal the wattage output of the secondary coil. Like all other devices, however, the transformer is not 100 per cent. efficient, though if well designed it should have an efficiency of better than 90 per cent. The losses in the transformer consist in what is known as core and copper losses, the percentage of loss depending upon the construction of the device. **If a transformer which is in good order operates at high temperature, it is evidence of lack of efficiency, as core and copper losses appear in the form of heat.**

TRANSFORMER CORE.—The core of a transformer consists of thin sheets of sheet-steel, technically known as "electrical steel." The sheets are painted on either side with an insulating compound and then clamped together into a solid mass. The thickness of the sheets of metal necessary for best performance is dependent on the cycle of the current the device is to operate on.

RATIO OF TRANSFORMATION.—A transformer may either be a "step up" or a "step down" transformer. A step down transformer is one in which the secondary voltage is lower than the voltage impressed upon the primary, and the amperage correspondingly greater. For instance, if a transformer were 100 per cent. efficient and ten amperes at 100 volts ($10 \times 100 = 1{,}000$ watts) were taken from the supply lines, and in the process of transformation the voltage was lowered to 50, then the secondary amperage would be 20, because 1,000 watts ÷ 50 volts = 20 amperes, and with 100 per cent. efficiency the primary wattage divided by the secondary voltage must and would be equal to the secondary amperage. This always holds true, subject only to modification by the losses inherent in the transformer itself.

A step up transformer is one in which the voltage induced in the secondary is higher than the voltage impressed upon the primary, and the amperage correspondingly lower, thus reversing the action of the step down transformer. As in the case of the step down transformer, however, the wattage of the secondary will be equal to the wattage of the primary, less the losses inherent in the device itself.

The ratio of transformation depends upon the relative number of turns of wire in the primary and in the secondary. If the number of turns in the primary exceed the number of turns in the secondary, or in other words if there are a greater number of turns of wire in the primary than in the secondary coil, the action will be that of a step down transformer. In the case of a projection transformer, the voltage of the secondary must be just sufficient to force the desired number of amperes against the resistance of the secondary circuit and the arc.

This is easily calculated. For example: A transformer with 100 turns in its primary and 10 turns in its secondary coil, will have a transformation ratio of 10 to 1, and if the primary voltage be 100, the secondary voltage, at no load, will be 10. If 10 amperes flow in the primary of a transformer having a transformation ratio of 10, then 10 x 10 amperes will flow in the secondary. The whole matter is summarized in the following:

Primary voltage: Secondary voltage = primary turns: secondary turns.

Primary amperes: Secondary amperes = secondary turns: primary turns, from which it is evident that, except for losses in the device, the wattage of primary and secondary will always be equal.

In examining the step-down transformer it will be found that the wires of the secondary coil are larger than the wire of the primary coil. This is because of the fact that the secondary amperage will be higher than the primary amperage, hence a wire of larger capacity is required.

The coils are completely insulated electrically from each other and form the core, but magnetic lines of force pass through insulation just as though it were not there.

RELATIVE POSITION OF THE TWO COILS.—While Fig. 197 shows the theoretical construction of the transformer, in actual practice the two coils are either wound one over the other, or they are placed side by side. In any event they are as close together as they can possibly be gotten, in order that the secondary coil be located in the strongest part of the magnetic field set up by the action of the primary coil and the core.

Broadly, this describes the general plan of construction and action of the transformer. Those who wish to delve more deeply into the matter of transformer construction and action may do so by consulting Hawkins' Electrical Guide No. 6, pages 1377 to 1456, wherein will be found a very complete, well illustrated description of the construction, the theoretical and the practical action of the transformer.

LOW VOLTAGE TRANSFORMERS.—For use on projection circuits, where the supply is alternating and it is for any reason not deemed expedient to rectify the current by means of a motor generator or mercury arc rectifier, there are a number of devices which are in fact nothing more or less than low voltage transformers. These transformers are made especially for use on projection circuits. They pass under various trade names. The three best known and most largely used are the "Economizer," which was the invention of J. H. Hallberg; the "Inductor," which is the product of the Nicholas Power Company, and the A. C. to A. C. "Compensarc," which is made by the Fort Wayne branch of the General Electric Company. They are all of the type known as "constant current transformers."

These devices take A. C. directly from the supply lines and deliver A. C. secondary current at arc voltage. They are all so constructed that the amperage of the secondary may be altered, usually in three steps, merely by the manipulation of a suitable switch connected to taps from the primary winding, (see Fig. 200), modified by the fact that in the older types of one of them, the economizer, the change in secondary amperage is accomplished by means of changing the primary connections, either directly or by means of changing the position of a plug fuse, instead of by means of a switch. They are, of course, all of them step down transformers. The maximum capacity of these transformers is 60 amperes, but most if not all manufacturers make a special high capacity instrument.

We would suggest to manufacturers of this type of transformer that instead of the regular stock transformer having a range from 40 or 50 to 60 or 65 amperes, as is the present practice, the purpose would be very much better served if such devices had a range of from 50 to 80, because 50 is as low an alternating current amperage as ought to be used for the projection of modern motion pictures, and 80 amperes is none too high for good work.

ADJUSTMENT.—The change of secondary amperage usually is accomplished by means of "tapping in" on the primary coil. This is illustrated in Fig. 200, in which A-B-C are wires connecting with the primary coil at various points, and D the adjusting switch of the transformer. Remembering that the E. M. F. and the amperage of the secondary is dependent upon the relative number of turns of wire in the primary and scondary, it will readily be understood that the altering of the position of switch D would alter the voltage and amperage of the secondary, since it would add to or reduce the active turns of wire in the primary coil. We believe no further explanation of this point is necessary, since the drawings and what has already been said, should make the matter sufficiently clear. Change in secondary amperage may also be accomplished by altering the position of the primary and secondary coils with relation to each other.

WIRE SIZES.—Where the projection circuit is served by an Inductor, Economizer, or Compensarc of 60 amperes secondary capacity, the usual custom is to install primary circuit wires of only sufficient capacity to carry the primary current, which will be decidedly less than the secondary current. We would, however, recommend that the primary and secondary circuit wires be of equal size, with a capacity of, say, 70 amperes, because in case something goes wrong with the low voltage transformer it may become necessary to temporarily install a rheostat, and if this be done, certainly one would not wish to pull less than 60 amperes, under which condition the wires of the primary circuit would be too small.

PERMISSIBLE TEMPERATURE.—See Pages 460, 461.

THE CHOKE COIL.—The choke coil, also called a "reactance" coil, is diagrammatically illustrated in Fig. 201. It represents what might be called magnetic resistance. If an iron core consisting, in practice, of thin sheets of metal, be built up, and one of the insulated wires of an alternating circuit be wrapped a number of times around it, as shown, magnetic reactance will be set up, which will have the effect of offering resistance to current flow. This is also called "magnetic kick." The magnetic field set up around the core of the coil has the effect of creating a counter E. M. F., which opposes the line voltage and reduces it. The practical effect upon current flow is essentially the same as that of the rheostat, but the choke coil is very much more economical in operation than is the rheostat, though it is not nearly so satisfactory for the production of projection light as is the transformer or auto transformer, or even the rheostat, largely by reason of the fact that it has a tendency to produce flaming at the carbons; also projection light from an arc supplied by a choke coil usually has a harsh, bluish, very unpleasing tone.

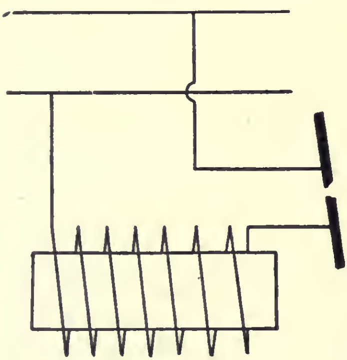


Figure 201.

TWO WIRE TO THREE WIRE.—Transformers may be built to take current from a two wire supply and deliver to a three-wire system, as per Fig. 202.

MULTIPLE CONNECTION. — Projection transformers of the same voltage and cycle rating may be connected in multiple in order to increase the amperage at the arc. To accom-

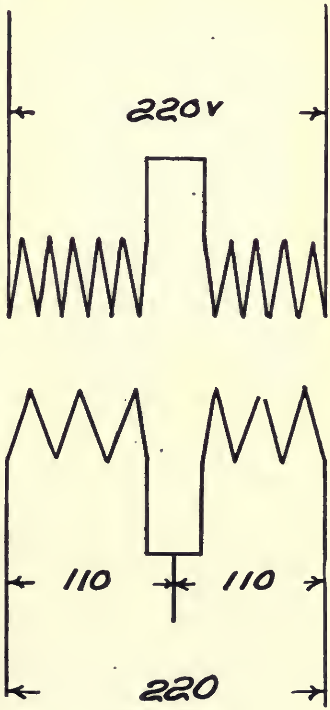
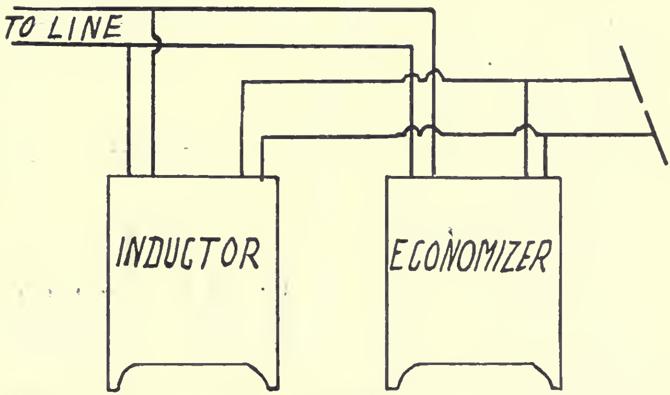


Figure 202.

plish this, connect the two economizers, compensarcs or inductors (an economizer and a compensarc, a compensarc and inductor or an inductor and economizer may be thus connected) to the supply separately, just as though each was to work alone, then connect the secondaries as shown in Fig. 203.

Having made this connection, it is permissible to set one transformer at its maximum and the other at its minimum capacity. By this arrangement a very wide range of current flow is available.

GENERAL ELECTRIC A. C. TO A. C. COMPENSARC.—This device is made by the Ft. Wayne branch of the General



MULTIPLE CONNECTION. SWITCHES AND FUSES OMITTED.

Figure 203.

Electric Company. Its general appearance is shown in Fig. 204. It is entirely self-contained, is well built and delivers 40, 50 and 60 amperes to the arc.

CAUTION: Before installing see that the voltage rating and cycles on the name plate correspond with that of the current supply.

LOCATION AND CONNECTIONS.—The compensarc should be so located that its controlling switch will be within easy reach of the projectionist from working position beside the projector. Any other location will greatly lessen the value of amperage control.

The connections are shown in Fig. 205. The "line" and "lamp" terminals are plainly marked on the top of the device, so that no mistake is possible in connecting. Connect the taps marked "line" to the supply line, through fuses and switch, and the taps marked "lamp" to the projector table switch. It makes no difference which wire leads to upper or lower carbon.

Figure 204.

The compensarc employs the means of changing secondary amperage illustrated in Fig. 206, in which A-B are small reactance coils which are cut in or out of series with the primary coil by means of switch lever, which swings to the left, its outer end carrying the handle seen on the top Fig. 206. Tracing the current, Fig. 206, you will see it must pass through both coils A and B, but with the switch making contact with E, coil B is eliminated, and with the switch in contact with F both coils A and B are cut out.

The claim is that by this plan a constant current is secured at varying arc voltages.

To determine whether or not all the switch contacts are in good condition, start the arc on low and then watch the effect on the screen illumination as you move the switch to intermediate and high. If the device is in good order on all steps the effect will be quite visible.

HALLBERG ECONOMIZER.—The Hallberg A. C. to A. C. economizer is nothing more or less than a low voltage transformer of the semi-constant current type, designed especially for use on projection arc circuits. It takes A. C. at line voltage and delivers A. C. at arc voltage. "Semi-constant" means that, according to its manufacturer's claim, it will receive the supply at fixed potential, but will deliver current

A-C. COMPENSARCS

Approved by the National Board of Fire Underwriters — **60, 50, 40 AND 25 CYCLES 110 and 220 Volts**

KW.	VOLTS	60 CYCLES		50 CYCLES		40 CYCLES		25 CYCLES		NET WT. in Lb. (Apprx.)	DIMENSIONS IN INCHES (Approx.)		
		CAT. NO.	SHIP. WT. in Lb. (Ap-prox.)	CAT. NO.	SHIP. WT. in Lb. (Ap prox.)	CAT. NO.	SHIP. WT. in Lb. (Ap-prox.)	CAT. NO.	SHIP. WT. in Lb. (Ap-prox.)		Height	Width	Length
2	110	223736	160	223922	170	223920	170	223918	180	135	22¼	10	12
2½	220	223737	180	223923	190	223921	190	223919	200	155	23¼	10	12

NOTE.—Compensarcs can be built for any three specified ratings of current at 35 volts at the arc. Standard rating of 40-50-60 amp., 35 volts, will be furnished wherever it is possible.

to the arc at practically steady amperage flow, regardless, within reasonable limits, of the length of the arc.

Fig. 207 is the diagrammatic representation of the latest

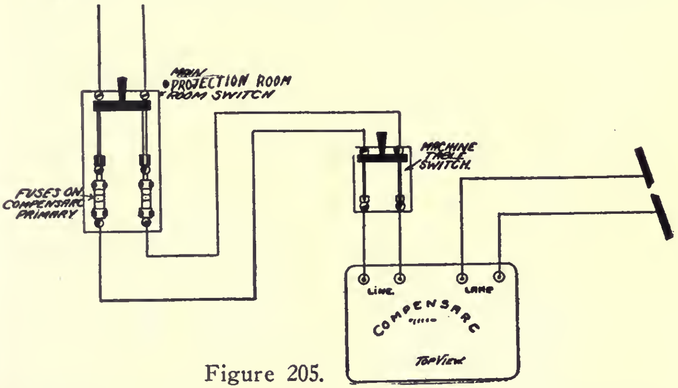


Figure 205.

type of Hallberg economizer. The two wires marked "to lamp" are the terminals of the secondary coil, one of which should be connected to the upper and one to the lower

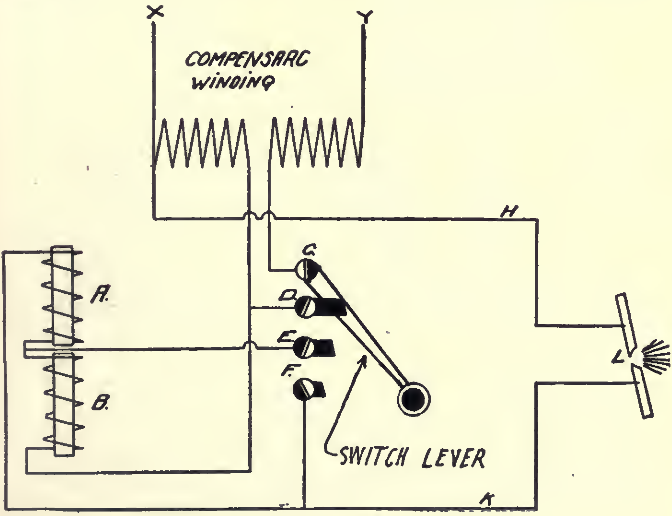


Figure 206.

carbon of the lamp. It makes no difference which is connected to the upper or lower carbon.

The primary winding is supplied with three tap connections which are attached to the contacts of the dial switch, the governor handle of which is seen on top of the economizer. The central point connects to one side of the supply circuit.

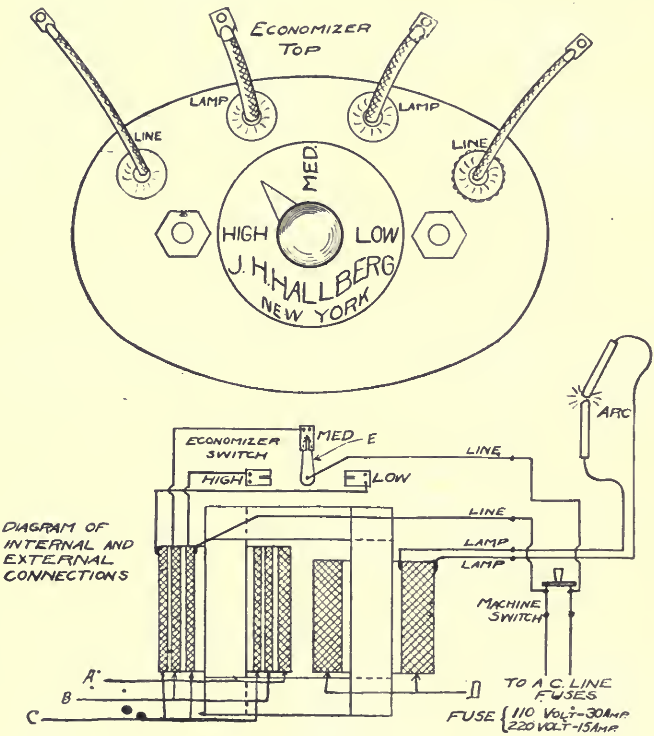


Figure 207.

The other side of the supply circuit is connected directly to the primary coil. A handle with a pointer serves to set the dial switch at high, medium or low.

The old designs of the economizer do not have this switch, but instead have three tap leads as per Fig. 208, in which terminal 4 represents one end of the primary winding, and terminal 1 the other end. A-B-C, Fig. 208, are fuse receptacles, and leads 2 and 3 are taps connecting to the primary coil as per Fig. 200, page 546. If a fuse plug of sufficient capacity to carry the primary current be placed in receptacle C, with receptacles A and B empty, then as you will readily see, the whole of the primary coil will be in use. This connection is designed for use where the primary voltage is a little above normal, or when you require the lowest amperage the economizer will deliver. If the fuses be removed from C and placed in A, then a proportion of the primary coil will be cut out, which will have the effect of raising E. M. F. of the

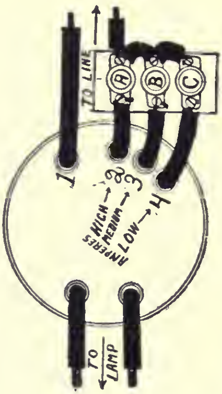


Figure 208.

Figure 209.

secondary voltage, hence the amperage at the arc. The fuse plug should be in receptacle A when the voltage is a little below normal, or when the highest available amperage is wanted at the arc.

CAUTION.—Do not unscrew fuse plug while the arc is burning. If you do an arc will be formed when the fuse disconnects from its contact, which will probably result in a ruined fuse receptacle. Aside from this the arrangement is cheap, practical, and one which should never give trouble.

Fig. 209 shows the appearance of the latest Hallberg economizer. The projector table switch should always be on the line or primary side of the economizer.

POWER'S INDUCTOR.—Power's Inductor, Fig. 210, consists of a well insulated, strongly clamped laminated core with the primary wound on one side or leg of the core and the secondary on the other. The casing consists of a cast-iron front and back, with a perforated fibre cover. On the front, at the top, two wires emerge, underneath which, on the casting, is the word "lamp." These two wires connect directly to the carbon arms of the projector lamp. It makes no difference which wire you connect to the upper or lower carbon arm. At the rear side, near the top, the two primary leads come out. They should be connected to the supply, as per Fig. 205, Page 555. On the face of the front casting is a handle which operates a single-pole knife switch, located on the opposite side of the casting. When this switch is thrown so that its finger points toward "high" you are getting the maximum amperage, approximately 65 if the supply voltage is 110. When it points to "medium" you are getting a medium amperage, and when it points to "low" you are getting lowest amperage transformer will supply.

Figure 210.

The inductor is designed for a maximum of 65 amperes on "high," 54 on "medium," and 45 on "low" when used on 110 or 220 volts, it being, of course, understood that you cannot use 110 volt inductor on 220, or a 220 on 110. In other words, you must have an inductor suitable to the voltage of your supply; also it must be suitable to the cycle of the current you use, though the inductor may be used on voltage ranging 10 per cent. below to 10 per cent. above that for which it is rated, but in one case there will be a corresponding increase, and in the other a decrease in its rated amperage. The inductor is designed for a maximum temperature rise of 50 degrees Fahrenheit above the surrounding atmosphere, and ordinarily its temperature will not exceed 30 degrees in excess of the surrounding air. It occupies 12 x 14 inches floor space, is 19 inches high, and weighs approximately 100 lbs. Its efficiency rating will compare favorably with others.

Automatic Arc Controls and Mechanical Arc Feeds

MODERN projection practice demands the elimination of the hand fed projection arc lamp, because the hand fed lamp only supplies evenness of screen illumination when the feeding of the carbons is given very much closer attention than is ordinarily the practice.

There are now on the market several devices by means of which the separation of the carbon points of the arc lamp may be either automatically or semi-automatically maintained at any desired distance of separation, and while these devices cannot be entirely depended upon to maintain exactly the desired separation under all conditions, still a well designed arc controller, either of the automatic or mechanical feed design, will require but very little attention on the part of the projectionist, and if there be no change in amperage should maintain the required separation without attention, either during an entire show or during the burning away of an entire set of carbons.

AUTOMATIC ARC CONTROLLERS.—The style of apparatus accomplishing automatic regulation of the arc is dependent upon the variation in arc voltage for its operation. This type of apparatus has an adjustment provided by means of which it may be set to automatically maintain any desired distance of separation of the carbon points. The mechanism is operated by a small motor, and changes in the arc voltage are depended upon to alter its speed. A well designed automatic arc control, which is kept in proper condition and adjustment, ought to maintain a practically constant separation of the carbon points, or in other words a practically non-variable arc length.

ARC VOLTAGE.—It may be convenient to users of this book if we here briefly explain just what is meant by "change in arc voltage," although that is fully set forth elsewhere, see Page 399. When an electric arc is operating, a stream of gas, or vapor exists between the carbon tips. This gas or vapor is the product of volatilization of carbon. It is a high-resistance conductor of electricity, and what is known as "arc voltage" is the pressure necessary to force the required amount of current across the gas stream from one carbon tip to the other. The voltage necessary to do this with a given distance of carbon separation will vary somewhat, according to the kind and amount of gas present, but with any given condition as to gas (and the gas condition is constant for any given carbon combination, provided the core does not drop out, or be missing altogether, or the arc be not exposed to excessive draft or sudden current disturbances or variations) the arc voltage will be directly dependent upon the distance between the carbon tips.

Reduced to simple terms this means that, in practice, every change in distance between the carbon tips of an arc alters the arc voltage, because it operates to change the resistance of the arc. As the distance between the carbon points increases the arc voltage rises, since a higher voltage is necessary to force the current across the wider opening. Conversely, as the distance between the carbon tips is decreased the arc voltage is reduced.

MECHANICAL ARC FEED DEVICES.—The purpose of these devices is to feed the carbons together at a rate of speed exactly equal to the speed with which the carbon is consumed. They take their driving power directly, or semi-directly from the motor which drives the projector, and if the speed of the driving element itself be constant, and the rate of consumption of the carbon itself be constant, there is no reason why the mechanism cannot be so adjusted that the desired separation of the carbon points will be maintained at a practically constant value. It is evident, however, that any change in the amperage will alter the rate of the speed of carbon consumption, and will therefore necessitate a change of the rate of feeding. As a matter of fact, however, the average projectionist does not often change the amperage, and when he does the altering of the speed of feeding is a simple matter, and easy of accomplishment.

It may therefore be said that, always provided the device be well designed and well constructed, either the automatic arc control or the mechanical arc feed will serve an excellent purpose. Each type of apparatus has its advocates. The automatic type cannot be used to regulate an A. C. arc. We would therefore advise prospective purchasers to examine carefully into the relative merits of the automatic and mechanical arc feeds, and to decide for themselves which will best suit their needs. The mechanical arc feed can be used for either a D. C. or an A. C. arc.

WHY CONTROLLERS SHOULD BE USED.—A further definite statement of why arc controllers should be used is perhaps in order. In the first place, if a hand-fed arc be used, in order to secure maximum results in evenness of screen illumination, and maximum returns in screen illumination per k. w. of energy expended, it is absolutely essential that the projectionist remain constantly beside the projector, feeding the carbons a very little at a time, and very frequently—in fact, every few seconds. In no other possible way can a perfect centering of the spot at the aperture be maintained. As a matter of fact not one projectionist in a hundred fulfills this condition. This is sometimes due to the fact that the multiplicity of duties imposed upon him by the theatre management will not admit of his doing it. In other cases he does not do it because he is just too careless or too lazy,

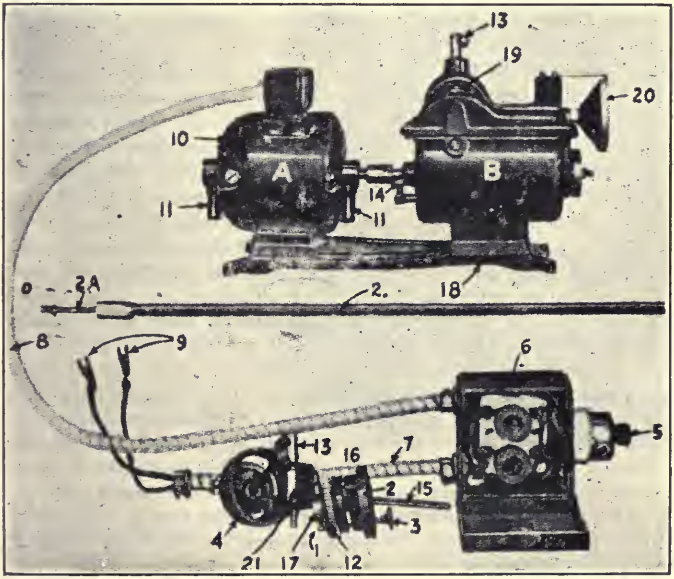


Plate I, Figure 211.

but no matter what the reason may be for such failure, the result is bad, and **justification of the investment necessary for proper arc control is more than ample.**

In considering matters of this kind, the theatre management will do well to remember that after it has invested anywhere from a few thousand to a half million dollars in a theatre building, and has paid large sums for its furnishing in the finest possible way, its ventilation in the most complete possible manner and its artistic lighting and has paid large sums for film service rental, it cannot possibly be good business to attempt to save a comparatively small sum of money by the investment of which the very heart of everything, the projection light source, will not only operate more economically and efficiently, but also will give a more even, constantly brilliant screen illumination.

We strongly advise all exhibitors using an arc light source for projection to install arc controls.

FULCO SPEEDCO AUTOMATIC ARC CONTROL is the re-designed and improved arc control formerly known as the Speedco.

The Fulco Speedco Automatic Arc Control is of the automatic type. It makes use of two basic principles, viz: Mechanical and electrical. The device is mechanically well made, and the experience of years has proven that it may be depended upon to perform the duty for which it is designed.

By referring to Plate I, you will see that the control consists of a small motor, A, directly connected through a flexible coupling to the controller mechanism, B. Controller B is connected to the arc lamp through the mechanism and rods illustrated in Plate II. The general assembly of the whole is shown in Plate V.

The controller is illustrated, in detail, in Plate I, in which 6 is the fuse box, 5 the snap switch which operates motor A, 8 the conduit protecting circuit connecting motor A and fuse box 6, 7 the conduit protecting circuit connecting the fuse box to the projector table switch, as shown in Plate IV. Beside the fuse box, to the left in Plate I, is the disassembled assembly illustrated in Plate II, in which 2 is the hand carbon feed wheel, 3 the thumb screw which locks the hand control to the mechanical control, 12 the gear operating the lamp carbon feed rod which is driven by gear 6, Plate II. Rod 2 and 2A in Plates I and II are the same, they being the rod which connects the control to the lamp carbon feed handle. This rod is adjustable in length, because rod 2A, which is square in form, telescopes into a square opening in rod 2.

Plate III illustrates the mechanism contained in controller B, Plate I. In Plate III gear 10 in the left hand illustration is the one which meshes with gear 44 in the right hand illustration (the right hand illustration being the under side of the cover of controller B, Plate I) which latter, through bevel gear 50, drives rods 2 and 2A, Plates I and II.

Now follow closely: Spring 41, Plate III, is attached to part 23 by slipping the bend in the end of spring 41 into eye hole 22 of part 23. When cover 40 is in place and tension is supplied to spring 41 by means of adjusting dial 20, Plate I, which operates on threaded bolt 45, Plate III, it has the effect of holding part 23, Plate III, back in the direction of arrow point 34, Plate III.

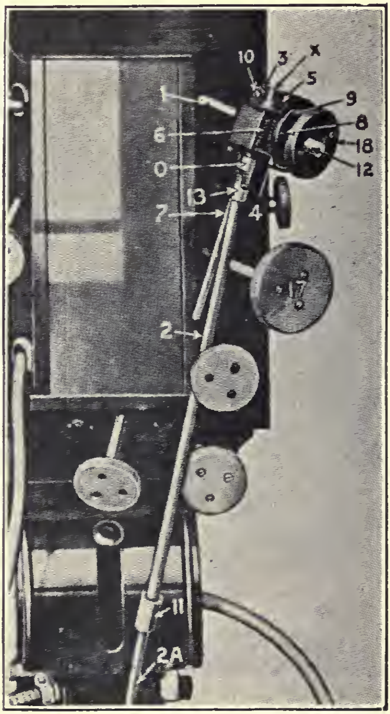


Plate II, Figure 212.

Part 28-28 are governor weights attached to governor yoke 27 by means of hinge pins 35 and 47, and right here is what might be termed the heart of the whole machine. Part 33 swivels on part 32, and the whole governor is rigidly attached to the main driving shaft by pin 38 in part 27. Part 31 is a steel tooth attached to part 23, and protruding ⅛ on an inch on the side next to wheel 16. The parts between 27½, which is a ball-bearing, and part 26, which is another ball-bearing, comprise the entire governor assembly, which revolves at the speed of the motor armature shaft, with which the controller driving shaft is directly connected, as shown in Plate I. Weights 28-28 are normally held in, in the position shown in Plate III, by means of spiral spring 41, which holds part 23 back against ball-bearing 26, whcih in turn presses back part 32, carrying pins 25 which bear on the inner end of arms carrying weights 28-28. Before proceeding any further, study this action closely and get the action clearly fixed in your mind.

And now here is how the mechanism operates. The motor runs constantly, but at a speed varying with the arc voltage.

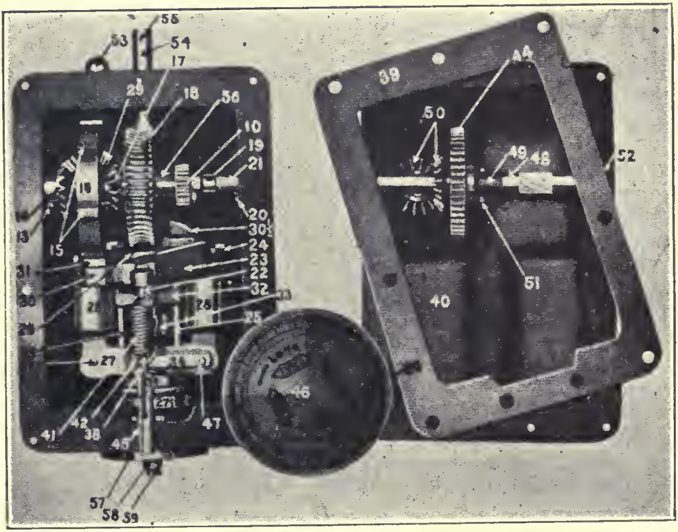


Plate III, Figure 213.

Its speed increases as the voltage is increased by the increasing length of the arc. As a result of the increased motor speed the tendency of weight 28-28 to be carried out by centrifugal force, against the pull of spring 41, has the effect of overcoming the pull of the spring and forcing part 32, ball-bearing 26, and part 23 ahead, which causes tooth 31 to engage with one of the stop teeth, 15, Plate I, on wheel 16.

Gears 14, 17 and 29 form what is known as a "differential." Gear 29 is attached to wheel 16, gear 14 to shaft 19 by means of pin 13, and gear 17 to gear 18. Underneath gear 18 is a worm gear attached to the shaft connecting the controller to the motor; in other words, to the main driving shaft. This worm drives worm gear 18, which is mounted upon, but is not attached to shaft 19; in other words, shaft 19 merely serves as a spindle upon which gear 18 revolves. When the motor is running, but with insufficient speed to cause the governor to operate, or in other words when the motor is running and the arc not being fed, gear 18 and wheel 16 are driven continuously. Wheel 16, which is also loose on shaft 19, being free to turn, gear 29 simply runs around on gear 14, but without revolving gear 14 which is pinned to shaft 19, as is also gear 10 which operates gear 44, the latter in the right-hand illustration. When the governor operates, however, it forces out tooth 31, which engages with one of the teeth on wheel 16, thus preventing the wheel from revolving, whereupon, (remember that gear 18 and wheel 16 are loose on shaft 19) since gears 18 and 17 revolve continuously, and since gear 29 locks gears 14 and 17 together when wheel 16 is not revolving, shaft 19 is rotated, together with gear 10 and gears 44 and 50, and thus the carbon feeding mechanism is operated, and the carbons fed together until the arc voltage is sufficiently reduced to slow the motor down until spring 41 pulls governor weights back again, thus releasing wheel 16 and unlocking the differential, whereupon the carbon feeding mechanism stops.

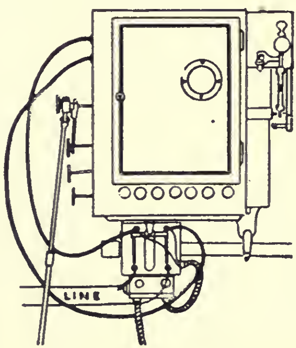


Plate IV, Figure 214.

All that sounds very complicated, but it really is not. On the contrary it is very simple once you get the idea of the action of the differential.

All gearing is fully inclosed, therefore protected from the grinding action of dust mixed with lubricant.

ADJUSTMENT.—The longer the arc the higher its voltage, therefore the faster will the motor of the controller run, and the speed necessary to cause tooth 31, Plate III, to engage with the teeth on wheel 16, Plate I, will depend upon the tension given spring 41, Plate I, by adjusting dial on wheel 20, Plate I, to maintain any desired arc length.

SUPPORTING STANDS.—Plate V illustrates different types of supporting stands. At the left the controller is seen on the floor, in the center raised about six inches, and at the right it is raised up about two feet, though the last stand can be made up, on special order, to any height required, as the supporting column can be made longer. This brings the control to any desired height, and so accommodates those extreme conditions which are at times met.

Either type of stand may be had with the outfit at a small added cost, remembering that the rod which connects the controller with the carbon feed handle is adjustable as to length, therefore, the use of the lower stand is optional, but the last or higher stand requires a telescoping rod of about half the length of those ordinarily supplied.

We advise the last or higher stand, as this raises the device out of the dirt, and looks neater; also it affords a better operating position, as it is not necessary to stoop over when making an adjustment. The stands are constructed so as to catch and hold any oil which may leak from the controller, thus keeping the floor clean and free from oil.

CONNECTING THE CONTROLLER.—When the controller is unpacked, examine the packing material very carefully to make sure it contains no small parts. The shipment will consist of the following: the controller, motor and base connected in one unit, with the necessary switch, fuse box, fuses and wire circuits protected by a flexible conduit, steel rod and tube, universal joint, fibre knobs and gearing necessary to attach the gear to the carbon feed rod of the arc lamp.

After unpacking and inspecting the parts, proceed as follows: First, set the controller and motor A and B, Plate I, on the floor immediately beneath the carbon feed handle of the arc lamp, though if necessary the controller may be set a little to one side, or a little back of the carbon feed handle of the arc lamp. This may be necessary in some cases where lamp controller handles interfere with the rods 2 and 2A, Plate I, or where the conduits coming up out of the floor prevent locating the controller in exactly the desired spot. It is, however, desirable that rods 2 and 2A, be as nearly perpendicular as possible, because universal joints 13, Plate II, will not work properly if rods 2 and 2A are set at too great an angle. This idea is illustrated in Plate V.

Switch box and switch, 5 and 6, Plate I, should be attached to the projector table switch casing, either on its under side, or to the side of the casing. This may be done by drilling suitable holes and fastening box 6, Plate I, to the projector table switch casing, somewhat after the fashion shown in Plate IV, by means of suitable bolts, after which a 13/16 of an inch hole must be drilled in the projector table switch box cover to receive the BX of circuit 7, Plate I. The only electrical connection necessary is to attach terminals 9 of circuit 7, Plate I, to the terminals of the projector table switch at the end of the switch which will be dead when the switch is open. If you attach it to the other end of the switch, the motor of the arc control will be subject to high

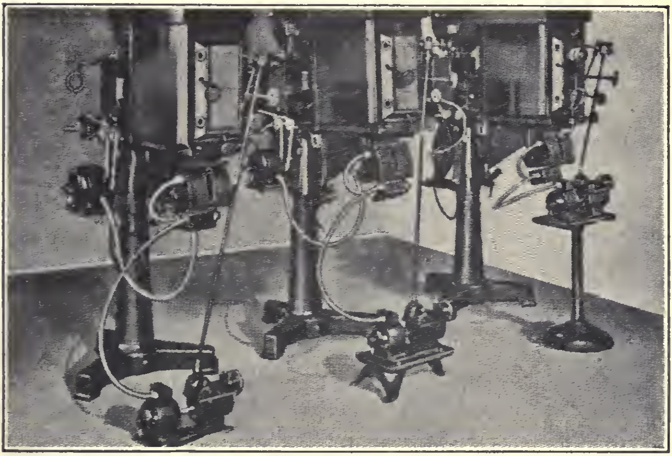


Plate V, Figure 215.

voltage, high enough to cause the carbon feeding mechanism to operate, unless switch 5, Plate I, be open. See "Caution," page 569

Do not attach the controller anywhere else except to the binding posts of the projector table switch which will be "dead" when the switch is open.

LUBRICATION.—The well formed by gear casing B, Plate I, shown with cover removed in Plate III, should be kept filled to the top of oil gauge 14, Plate I, using a good grade of dynamo oil. The oil is put in by removing thumb screw 19, Plate I, and the filling is continued until the oil reaches the top of oil gauge 14, Plate I. One filling of good lubricant should last about 500 hours, or in a house running 10 hours a day for about two months.

About twice a year the oil well should be drained. After draining fill the oil well with kerosene and let the controller run for a short time, after which drain the kerosene out and re-fill the well with fresh oil.

CAUTION.—You are cautioned against using Three-in-One, and other very thin much advertised oils, as they are totally unfit for the lubrication of a device of this kind.

The manufacturers recommend any good grade of dynamo oil, which can be obtained from your supply dealer, or from any reliable oil dealer. The oil sold by projector manufacturers for use on their projectors will serve very well.

OPERATION.—The controller will maintain the length of arc for which it is adjusted, and the length of arc it will maintain may be altered by turning adjustment dial 20, Plate I, in the direction as indicated to maintain a longer or shorter arc.

The voltage of your supply lines may change during the day, and repeat these changes day after day. Arc controller adjusting dial has its face laid off in numbered divisions, and there is a pointer, so that by making a note, or by taking a record of its operation as the dial is set at different figures, the controller can be re-set at those times when the current changes take place, without the necessity of making the daily experiment of adjusting a thumb screw or nut so as to maintain the desired arc condition. If the projection room is equipped with a reliable voltmeter it only requires a little observation to know exactly where to shift the speed controller dial to obtain the desired results from any given voltage.

CARE.—Examine the oil cups of the motor once a week and keep them filled with oil; also examine the commutator of the motor occasionally. In this connection see general instruction No. 7, Page 509, on care of the commutator. Should everything go wrong with the interior gearing of the control (very unlikely, though all things are possible) it will be necessary to return the entire mechanism to the factory for adjustment. It is not advisable that the projectionist himself attempt to repair the control mechanism. The explanation of the mechanism is not given with the idea of enabling him to repair it, but because we believe any man can work more intelligently with a thing if he understands its operating principle; also because the average man very naturally does not like to operate something he knows nothing about. We, therefore, provide him a better means of getting the knowledge he desires than by tearing the machine to pieces.

CAUTION.—The controller must under no circumstances be connected to alternating current, or to any voltage higher than 115. Always place snap switch 5, Plate 1, in the "open" position after extinguishing the arc.

When it is desired to resume operation, first strike the arc by hand and set it to approximately proper length, after which turn snap switch 5, Plate I, in the "on" position. This latter is important, because if the projector table switch be closed when the arc is not in operation, as is not infrequently the case, the controller motor would be subject to voltage sufficient to place the carbon feeding mechanism in operation; also, if current be taken from 110 volt direct current lines through a rheostat, the motor would be operating at line voltage, because with such a very small current flow, the rheostat would not operate.

HALLBERG CONTINUOUS FEED ARC CONTROL.— The Hallberg Continuous Feed Arc Control is of the automatic variety. Its operating theory is to a certain extent unique, and could not, it seems to us, be very largely improved upon.

In Fig. 216 the operating mechanism is shown. The principle of operation is as follows: In Fig. 216, 3 is a motor, to the upper end of the armature shaft of which driving worm gear 4 is rigidly attached. Worm gear 4 meshes with gear 10, through the train consisting of gears 5, 6, 8 and a gear on the right-hand end of shaft 9, which engages with gear 10. Arc lamp feed control rod 11 acts as a shaft for gear 10, and the gear and shaft may revolve independent of each other, or they may be locked together as follows: Knurled knob 13 operates what amounts to a brake shoe on the opposite, or back, side of the hub of fiber disc 12. When knurled knob 13 is slacked off, the carbons may be fed in the usual way by turning disc 12, but when knurled knob 13 is tightened up, feed rod 11 is locked rigidly to motor 3, through the gear train already described.

To strike an arc, the projectionist loosens knurled knob 13 by about one-half turn, which releases the gear train and motor. He then strikes the arc by hand, in the usual way, and adjusts it to approximately correct projecting conditions.

He then, in order to remove all possible lost motion in rod 11 and its connections, turns disc 12 slightly in the direction of feeding, and locks it to the gear train by means of knurled knob 13.

Under this condition motor 3 feeds the carbons together constantly and at a constant rate of speed. The projectionist must then adjust the speed of motor 3 by means of thumb screw 14. Part 17 is a coil of fine resistance wire, a part of which is in series with both the armature and field of motor 3. The connection is as follows: Wire 18 connects directly with the motor field and armature, and with the top end of resistance coil 17. Block 15 is moved up or down by means of thumb screw 14, riding on brass bar 17, with which its metal part makes electrical contact. On the back of part 15 a spring clip is carried which makes sliding contact with the raw wire of coil 17.

Having struck an arc and adjusted it to normal projecting as block 15 is lowered by rotating screw 14 in a clockwise

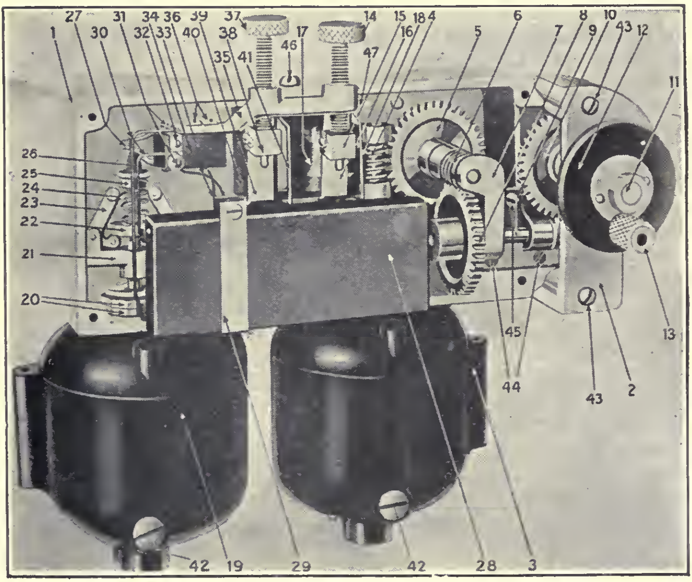


Figure 216.

direction, a greater amount of the resistance of coil 17 is brought into action, and since this resistance is in series with the field and armature of motor 3, the speed of motor 3 is reduced. Conversely, as screw 14 is revolved counter-clockwise, block 15 is raised, and the speed of motor 3 is increased.

Having struck an arc and adjusted it to normal projecting conditions, the projectionist next proceeds to regulate the speed of motor 3, by means of screw 14, until the carbons are fed at a speed just a very little less than is necessary to maintain the normal carbon separation. **In other words, speed of motor 3 must be so adjusted that the carbon separation will increase very slowly as the arc burns.**

THE AUTOMATIC END OF IT.—Motor 19, which is also a series motor, and identical in every way with motor 3, has, mounted on the upper end of its armature shaft, a governor very similar to an ordinary engine governor. This governor is rigidly attached to the armature shaft, and must rotate therewith. When the speed of the motor increases sufficiently, weights 23 are thrown outward by centrifugal force, thus raising part 22 against the pressure of coil spring 24.

Part 26 is a fiber cap attached to a steel spindle, which latter passes down through the center of the upper end of the governor center shaft, and is attached rigidly to part 26 by means of a screw in the face of part 22. The effect of this is, when part 22 is raised by the action of arm 23, part 26 is lifted vertically. Parts 27 are contact points, normally held slightly separated by spring action. When part 26 is raised by the governor, these contact points are forced together, which short-circuits the resistance of coil 17, thus increasing the speed of motor 3 and feeding the carbons faster, until such time as normal arc length is re-established, whereupon, the voltage being reduced to normal, the speed of motor 19 drops, the governor resumes its normal position, contact points 27 are separated and the resistance of coil 17 is reinstated in series with motor 3, thus reducing its speed to normal. This action all takes place at a very slight change in arc voltage—so slight that the change in carbon point separation is negligible.

Knurled knob screw 37 controls resistance coil 40, which is in series with the field and armature of motor 19. It operates precisely the same as does the mechanism controlled by screw 14, which we have already described. Resistance 40 is used for the purpose of establishing the point at which governor 21 will be brought into action. In other words, the projectionist may establish his arc length at whatever is the best projecting condition, then by the adjustment of screw 37 cause governor 21 to come into action at the proper time to maintain that arc length within the limits of a negligible fraction.

Twenty-eight is a static condenser coil. It is non-adjustable. Its only purpose is to minimize arcing at contacts 27, with which it is connected in multiple.

MOUNTING.—It is neither necessary or advisable to consume valuable space in the giving of detailed instructions for mounting, because complete installation instructions accompany each device.

In the Simplex type S a slide is provided, which takes the place of the removable slide in the rear of the lamphouse.

LUBRICATION.—Motors 3 and 19 are equipped with bearings which are presumed to require no oil. It will, nevertheless, be advisable to, say once in two weeks where it is an all-day house, or once a month for evening shows, to put **one drop** of mechanism oil in the armature shaft of motor 19, just where it enters nut 20, and **one drop** at a similar point on the armature shaft of motor 3. Also in upper and lower bearing for worn gear, as these are the only high speed parts of the controller.

CAUTION.—ONE DROP we said, mind you! Don't put more on unless you are looking for trouble. Use the same oil you use for the projector mechanism. DO NOT LUBRICATE THE GOVERNOR, OR ANY OF ITS PARTS.

About once a month remove the mechanism cover by taking out the four screws holding it, and put a little automobile grease on the face of the various gears. **Don't** smear on a lot of grease! Use a little judgment and common sense! If you use too much grease, particularly on gears 4 and 5, look out for trouble. Before putting on fresh grease, remove all the old, wiping the gears off clean. This will greatly decrease the wear on the gears.

Gears 5, 6, 8 and the one on the right-hand end of shaft 9, may be removed by taking out screws 44 and 45. **It is not, however, recommended that the replacement of these gears be undertaken by the projectionist. They should, and if properly lubricated will, wear until the whole device would**

naturally require a general overhauling, at which time the controller should be sent to the factory.

If properly cared for we see no reason why a general overhauling should be required in anything less than a three thousand or four thousand hour run—perhaps even a great deal longer.

Should anything go wrong with coil 40 or 17, they may be replaced by the projectionist by removing screw 31, loosening the screw at the top of clamp 29 and slipping out condenser 28. Next remove screws 46 (two of them) on top of the casing, whereupon the parts carying the resistance spools may be pulled ahead, and the spools will be released by removing the necessary two screws at the top and at the bottom. A new coil may then be slipped into place.

CAUTION.—In removing and replacing resistance coils be very careful to first thoroughly examine and understand everything so you can get the parts back where they belong.

CAP SCREWS.—The motor armature brushes must be examined occasionally and replaced with new ones when they wear out. If dirt and oil accumulate the result may be that the brush will stick in the guide tube or fail to make perfect contact. For these reasons the brushes must be examined now and then and also to make sure that they are not worn too short, because if these defects exist the motor will not start and will fail to feed the carbons. Remove the cap screws and carefully pull out the coil springs and brushes. In replacing be very sure that the brush slides freely in the guide tube and that the springs fit with secure contact on round part of square carbon brushes. Do not bend or stretch the brush springs! Do not fail to replace a used brush in such a manner that the concavely worn part fits the commutator in order to insure perfect contact.

PEERLESS AUTOMATIC ARC CONTROL.—The Peerless Arc Control is of the automatic type, and is by far the simplest, both in mechanical and electrical construction, we have yet seen.

It consists essentially of a small motor, Q, Fig. 217, which drives gear T by means of worm gear S, the latter attached to the armature shaft. Gear T is attached to and drives upright rod B, into which square rod G telescopes. This latter is to accommodate varying heights, or in other words, to cause the length of combined rods B and G to be adjustable. Rod G, through another pair of worm gears, drives carbon feed rod P.

When the carbons are not being fed, motor Q and the mechanism stands still. The running of motor Q, and therefore the feeding of the carbons, is actuated by means of a circuit passing from the motor to snap switch K, through the box to which conduit O is attached. The circuit contained in conduit O passes down through the apparatus contained in the box, and on through underneath the supporting stand to the motor.

The control may be used on any make of projector. It is designed to stand on the floor, as nearly as possible immediately under the arc lamp carbon feed handle, the complete assembly being illustrated in the diagram shown in Fig. 217, in which square rod G telescopes into a square opening in rod B, which makes the length of the combined

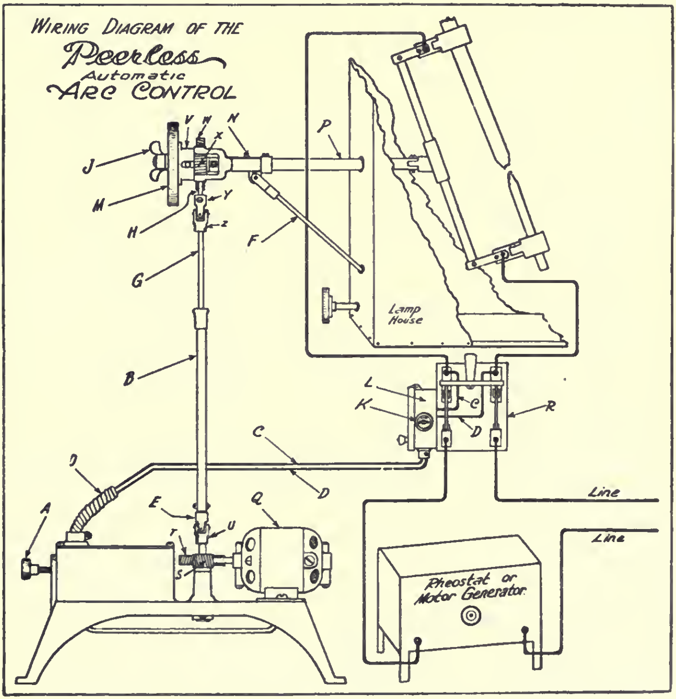


Figure 217.

rods adjustable to suit varying heights of the carbon feed rod from the floor.

The actuating element is completely inclosed and is sealed. When the machine is received you will find attached to one of the seals a printed warning that if the seal is broken the guarantee on the machine is voided.

For the benefit of the projectionist, who naturally dislikes handling something that he does not understand, we will say that there is no reason for breaking the seal, because the only thing inside of the sealed box is a relay exactly similar to the relay in telegraphic instruments, and a small, high resistance unit. The operation of the controller is governed by changes in arc voltage. Inside the sealed box are two highly sensitive magnets, in series with each other, which are connected directly across the line in multiple with the projection arc. The strength of these magnets will, therefore, of course change with each variation in arc voltage. At the end of the magnets is an armature attached to an upright, the upper end of which is arranged precisely the same as the "sounder" of a telegraph instrument, except that on one side is a fibre insulator.

This bar is normally kept pulled away from the magnet by the tension of a coil spring attached to adjusting screw A, Fig. 217, and when in this position, it rests against the insulator. When, however, the magnet pulls the bar over toward it, its upper end makes metallic contact which completes motor circuit CD, Fig. 217, and starts the motor running. It works thus: the stronger the tension on the spring attached to adjusting handle A, the greater the force the magnets will be obliged to exert in order to pull it over and complete circuit CD, or, in other words, start motor Q running. Suppose when the arc is adjusted to the best possible condition, the voltage is 55. We then turn adjusting screw A, Fig. 217, until motor Q stops just at the point where the arc is the way we want it. We will then readily understand that under this adjustment, as soon as the carbon is consumed and the arc voltage increased, the increased strength of the magnets will pull the armature over, complete circuit CD, and start motor Q running, thus feeding the carbons together, which process will continue until the arc voltage has dropped to normal, whereupon the spring will overcome the pull of the magnets, and circuit CD will be broken.

That is the way the Peerless works. It is simplicity itself, and the device has given general satisfaction. The movement of the armature at its upper end, where the contact is made, is only .006 of an inch.

The projectionist may adjust the controller to maintain any desired arc length. The manufacturers claim the sensitiveness to be such that the actuating element will act on less than 1/5 of a volt change. We cannot vouch for this, but a change of as much as one volt will not materially affect the position of the spot at the aperture, hence will not affect results on the screen.

The gear reduction is such that the motor armature must make 6,400 revolutions to one revolution of the carbon feed handle. Inside the sealed box is also a high resistance unit, connected in series with motor Q, Fig. 217. This permits some current to enter the motor at all times when the table switch of the projector is closed, which serves the purpose of reducing to a minimum the load which the circuit breaker has to break, thus eliminating any destructive spark. The actuating element is guaranteed indefinitely by the manufacturers, so long as the seals are not broken. All other parts of the instrument are guaranteed against defective material or workmanship for a period of one year from date of sale.

WARNING.—The manufacturers report an inclination on the part of the projectionists to break the seals and attempt to improve the adjustment of the relay points. You are warned against doing this, because you cannot improve the factory adjustment, and it is not at all likely that this adjustment will in any way be disturbed by an extended period of operation.

The gap must be from .005 to .006 of an inch. Anything more than that will cause the controller to be coarse in its operation. The best thing you can do is to let those points alone, but if you feel the voiding of the guarantee is not too much of a price to pay for looking at a very simple mechanism, and you do break the seals, then by all means confine your efforts to **looking;** but if you feel it is absolutely necessary to tinker with the relay, then secure a spacing gauge .005 or .006 of an inch thick, and be sure you leave the relay with exactly that gap.

The Peerless Arc Control can only be used where direct current is employed at the arc. It must be so connected that circuit CD will receive arc voltage only, which means that the connection must be made on the projection lamp side of

the rheostat, motor generator, or the mercury arc rectifier. It should, in fact, be made to the end of the projector table switch which is dead when the switch is open.

With the Power's, the Motiograph, or the type S Simplex, you disconnect the entire feed handle and rod from the lamp, and in its place attach the assembly sent with the controller. With the regular type S lamp, which has the carbon feed rod rigidly attached to the lamp, it is only necessary to remove the fibre handle and in its place attach the special feed assembly supplied for that type of lamp. Rod G is then slipped into rod B and the lower end of rod B is attached

Figure 218.

to the universal joint E, as shown in Fig. 217. Supporting rod F may be either attached to one of the lamp adjustment handles by means of clips supplied with the outfit, or you can drill a small hole in the rear lamphouse wall about five inches below the opening through which rod P passes.

Circuit CD is controlled by snap switch K. The controller may be purchased either with box L and snap switch K or without. Box L contains a fuse box and two plug fuses which protect the circuit. Snap switch K is on the outer wall of the box. If fuse box L is purchased, then circuit CD will be inclosed in flexible Greenfield conduit O. If box L is not purchased with the outfit, then it will be necessary to install a plug fuse box and a snap switch. Box L, or the fuse block, may be installed anywhere desired, but the best and most convenient way is to drill a hole large enough to admit the ½ inch chase nipple which projects through the back of the fuse box, the nut upon which will hold the fuse box in place, through the side of projector table switch box R, Fig. 217, and attach the box L on the fuse block thereto by means of suitable bolts. If box L is not purchased, then circuit CD should be inclosed in flexible conduit between the controller and the fuse block.

From box L on the fuse block, the circuit CD must connect to the binding post of the projector table switch, which will be dead when the switch is open. Before installing a new trim of carbons, placing snap switch K at "open" put in the carbons and let them burn in before closing snap switch K. This is advisable because the voltage at the arc is much lower while the carbons are burning in than it is afterwards. Fig. 218 illustrates the method of installation.

LUBRICATION.—Once a week slightly lubricate the gears with a good grade of automobile grease and at the same time oil the bearings and motor.

TEPECO MECHANICAL ARC FEED.—The Tepeco Mechanical Arc Feed consists of a very simple mechanism inclosed in a pressed steel case, taking its power from the motor which drives the projector.

With the Power's projector it is connected directly with a spindle of the speed control, which in turn connects to the motor armature, Fig. 219, so that the speed of driving is constant, regardless of the speed of the projector mechanism itself. A special coupler is provided for the purpose of making the connection; also a special spindle, which is a little longer than the Power's spindle. It is only necessary to slip out the Power's spindle and replace it with the special. The operation is not at all difficult. The mechanism is then connected with the carbon feed handle of the arc lamp with a flexible cable and a suitable mechanism.

A general view of the Power's installation is shown in Fig. 219.

When attached to the Simplex, the Tepeco is driven by means of a belt which connects a pulley on the side of the Tepeco mechanism to the motor which drives the projector.

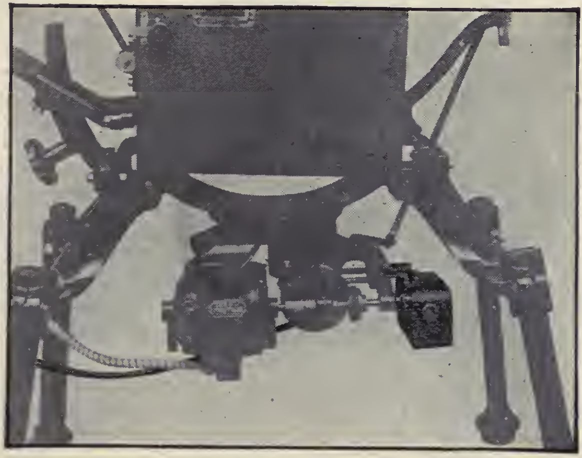


Figure 219.

A general view of the Tepeco attached to a Simplex is had in Fig. 220.

The Tepeco mechanism is connected with the carbon feed handle of the arc lamp by means of a flexible driving shaft inclosed in a suitable flexible mechanism.

On the end of the Tepeco mechanism casing is an adjustment thumb screw by means of which the speed of feeding may be either increased or decreased. On its face is a double pointed arrow. To increase the speed of feeding turn the thumb screw in the direction of arrow F, and in the opposite direction to decrease the speed of feeding.

The cover of the mechanism is merely pressed on. It is not held by screws and may be removed by inserting the point of a screw driver in the slot at either end of the casing and prying it off.

LUBRICATION.—A drop of the same oil that is used for the projector mechanism should be placed in the oil hole on the top of the Tepeco mechanism casing once a day, or twice a day if it is in an all-day house. The worm gear inside the casing should be kept lubricated with automobile or motor generator cup grease. Also a drop of oil should be placed on the two spindles the ends of which will be seen when the casing of the mechanism is removed, also on the spindle which protrudes through the casing on the back side. There is, however, no necessity for oiling these more than once a week.

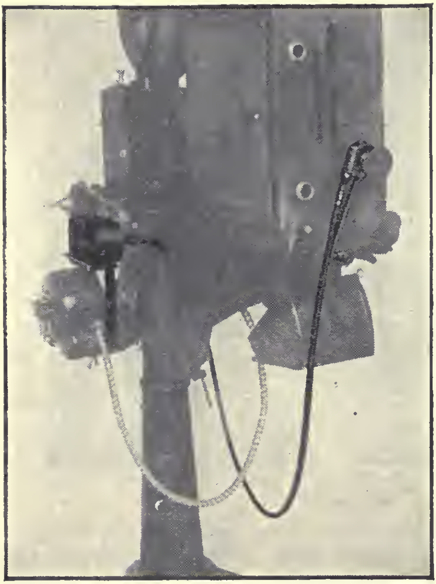


Figure 220.

NOTE.—Do not put any oil or grease on the big flat disc, the surface of which looks something like the face of a file.

Full instructions accompany each instrument, and the matter of installation is sufficiently simple that any projectionist should be able to attach the device to his projector. The device has been tried out very thoroughly and reports show it to be quite satisfactory.

MOTIOGRAPH MECHANICAL ARC CONTROL.—The Enterprise Optical Mfg. Company, manufacturers of the Motiograph projector, make and market a device known as an adjustable mechanical arc controller. It, together with the Motiograph lamp, is shown in Fig. 220-A. The following description will give you a working idea of the construction and operating principle of the device.

The motor, AF-1, Fig. 220-A, is mounted upon a bracket, which same is attached to the under side of the lamphouse, so that the entire device, motor and all, is readily accessible;

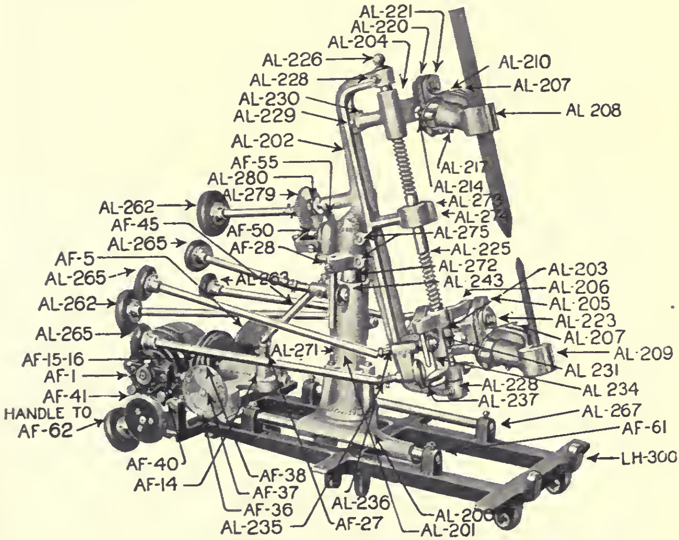


Figure 220-A.

also it is located well up out of the dust and dirt. On the motor armature shaft is a "worm," which same engages with a worm wheel attached to the outer end of shaft carrying friction disc AF-5. Friction disc AF-5 engages friction discs AF-15 and 16, and when so engaged the two latter discs are revolved. The supporting bearings for the shaft carrying friction disc AF-5 are a part of the bracket supporting the motor.

Friction discs AF-15 and 16 are mounted on carriage AF-14, the rear of which is supported on shaft AF-40; the front end is supported by rear end of shaft AF-61 by means of a tongue and groove connection.

Friction discs AF-15 and 16 are held together by the pressure of a spring. On one end of the shaft carrying these discs is a worm, which engages with a worm wheel on lower end of vertical shaft AF-27, which same connects to telescopic shaft AF-45, and by suitable means, with the carbon feed screw AL-225.

When shaft AF-40 is rotated it moves carriage AF-14, carrying friction discs AF-15 and 16 so that friction disc AF-5 is thrust further between or withdrawn from between friction discs AF-15 and 16. Since friction disc AF-5 is driven at constant speed by the motor it will be seen that rotating shaft AF-40 will have the practical effect of increasing or decreasing the speed of rotation of friction discs AF-15 and 16, hence the speed of feeding the carbons. The projectionist may therefore adjust the speed of carbon feeding at will, merely by rotating the knob on shaft AF-40.

In considering this it must be remembered that the worm gears, of which there are two sets between the motor and the carbon feed screw AL-225, act to hugely reduce the speed, so that a very fine adjustment of actual carbon feeding speed is possible.

While the makers of this and other mechanical arc controls claim it is possible to run a whole trim of carbons without any attention on the part of the projectionist, it is a question if this is entirely practical. However, in any event, any adjustment that may be necessary will be very slight, provided the projectionist uses ordinary care in adjusting the speed of feeding, and the possible necessary adjustment by hand we do not regard as in any way objectionable.

SIMPLEX MECHANICAL ARC CONTROL.—The Precision Machine Company, manufacturers of the Simplex projectors, have evolved a most excellent mechanical arc control, a description of which follows:

The control mechanism consists of a speed changing gear, mounted on spindle, A, Fig. 221. The control mechanism is so mounted that it may be moved sidewise with reference to electric motor B, Fig. 221. This feature will be described in detail further on. The speed-changing gear is driven differentially by the motor, through a train of three pulleys, one of which, C, Fig. 221, is mounted on the motor armature shafts, and drives both the projector mechanism and the arc control. The other two, D and E, are mounted on the spindles which carry the gears of the controller. Pulleys D and E are conical pulleys. They are driven from pulley C, Fig. 221, by means of a single half-inch flat, rawhide belt, as shown. This belt is kept permanently in line with the motor pulley by means of pulleys 1 and 2, Fig. 221, the upper one of which is mounted on adjustable tension lever 3, Fig. 221, so that more or less tension may be given the belt.

The central shaft of the controller, 4, Fig. 221, is connected through a square-shaft telescope, 5, Fig. 223, a flexible shaft, 6, Fig. 223, reducing gear, 7, Fig. 223, and a spring clutch, 8, Fig. 223, to the arc lamp feed handle, 9, Fig. 223. The gear casing of the control is carried on two rods, 10 and 11, Fig. 222. These rods are supported by the main frame, 12, Fig. 222, which carries the whole mechanism of the control, including the motor, which latter not only pulls the controller, but the projector mechanism as well.

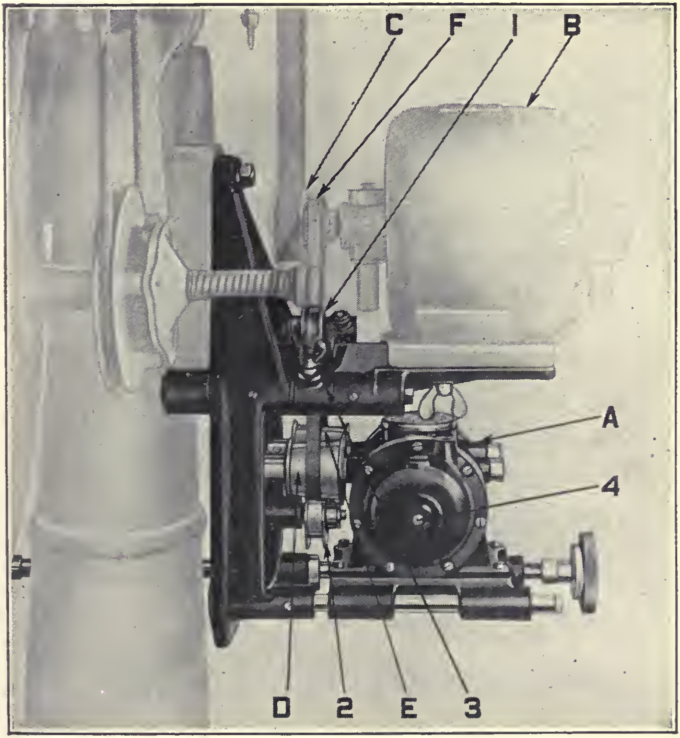


Figure 221.

Rod 11 uses main casting 12 merely as a journal. In other words, it revolves therein, and is held from moving endwise by means of collars 13 and 14, Fig. 222. The left-hand end of rod 11 is threaded, and these threads engage with similar threads in lug 15, Fig. 222, so that when hand wheels 16-16 are revolved by the projectionist, the whole gear casing and cone pulleys D, E, Fig. 221, are moved sidewise, and since the motor remains stationary and the controller driving belt is held stationary by means of pulleys 1 and 2, Fig. 221, the altering of the position of the gear casing alters the position of the belt on pulleys D, E, Fig. 221.

It will thus be seen that by revolving hand wheels 16-16, Fig. 222, the relative speed of pulleys D, E, Fig. 221, with relation to each other is altered.

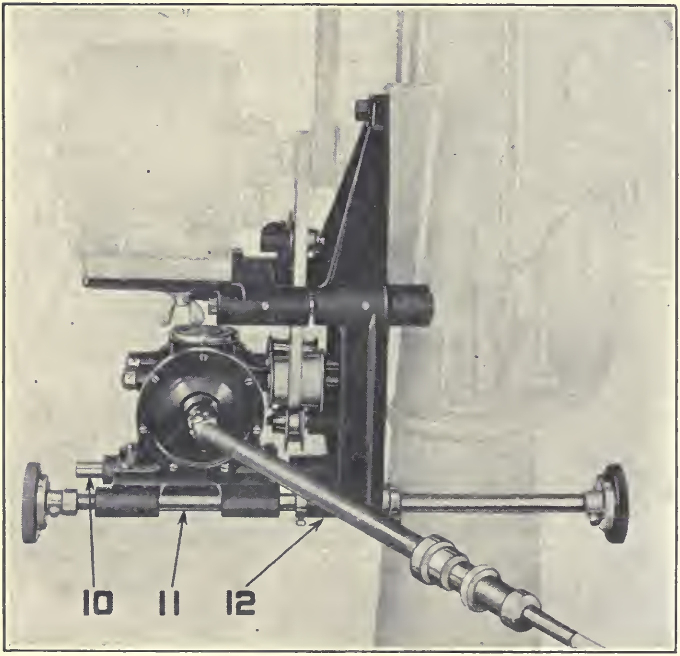


Figure 222.

Conical pulleys D, E are the driving elements of the differential, and the differential drives central shaft 4, Fig. 221, which connects, through flexible shaft 6, Fig. 223, with the arc lamp.

It is very difficult to explain the action of the differential, but when the driving belt is in central position pulleys D, E will run at exactly the same speed and under that condition shaft 4, Fig. 221, and shaft 5, Fig. 223, will remain stationary. If the position of the belt be altered so that pulley D runs faster than pulley E, then shaft 4 will be revolved in a

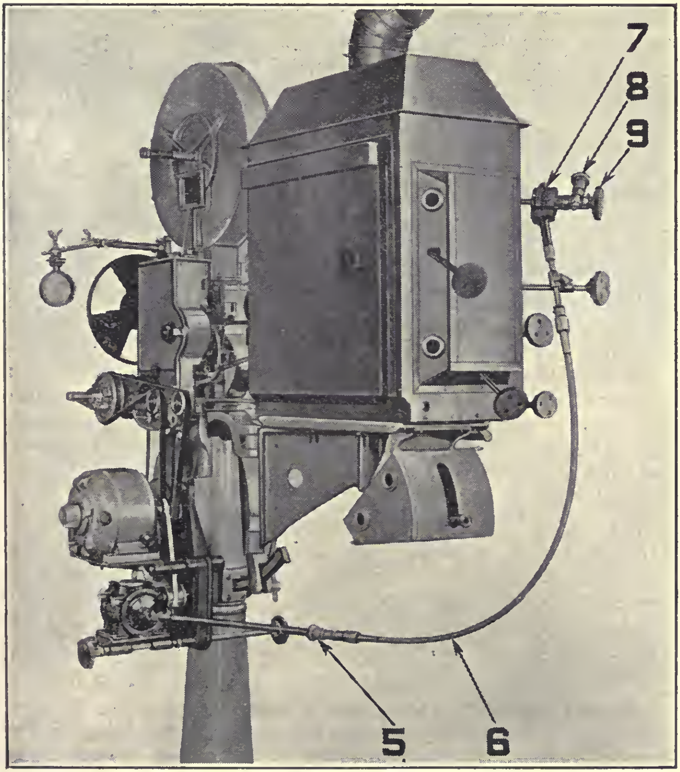


Figure 223.

direction that will feed the carbons together, and the greater the difference in the speed of the two pulleys, the faster the carbons will be fed. If, on the other hand, the belt be shifted so that pulley E runs faster than pulley D, then shaft 4 will revolve in a direction which will pull the carbons apart.

It therefore follows that by revolving knob 16-16, the projectionist may alter the speed of the feeding of the carbons, or may even reverse the action so that the carbons will be pulled further apart. The slope or inclination of pulleys D, E, Fig. 221, is such that an even tension on the belt is maintained throughout the whole range of adjustment, which is about one inch.

Spring clutch 8, Fig. 223, provides a frictional connection between the control mechanism and the carbon feed handle of the arc lamp. This provides means for adjusting the arc independently of the control, or, in other words, by hand, which same may be done without disconnecting the control from the carbon feed handle.

The projectionist may strike the arc and adjust the carbons to their proper position without in any way interfering with the operation of the control.

The rate of carbon consumption and the necessary rate of feeding for any given carbon size and current may be determined by experiment, and once the rate is determined and the control set for that rate, very little further attention is required unless the amperage be changed. But even, though, for any reason the rate of carbon consumption be changed, or the speed of the driving motor be changed, the necessary readjustment of the control is simply made and easily accomplished.

The control is ruggedly constructed, made of good materials, and it is mechanically very well made indeed. The feeding is entirely mechanical, no electrical devices being employed. We recommend the Simplex Mechanical Arc Control to the consideration of our readers. It has the approval of the projection department of Moving Picture World.

SIMPLEX HIGH INTENSITY ARC LAMP.—The Precision Machine Company, Inc., manufacturers of the Simplex Projector is putting out a mechanically fed and operated high intensity arc lamp. One of the main and unusual features is that it is available for use at any amperage from 70 to 120.

Fig. 223-A is a general view of the operating side of the lamp. The positive carbon is shoved through a hole in the center of gear 1 and through loose washer 2. In this washer is a broad headed set-screw, the tightening of which clamps the washer to the carbon so that, as positive carbon carrier 3 is carried forward by feed screw 4, the positive carbon is also carried forward.

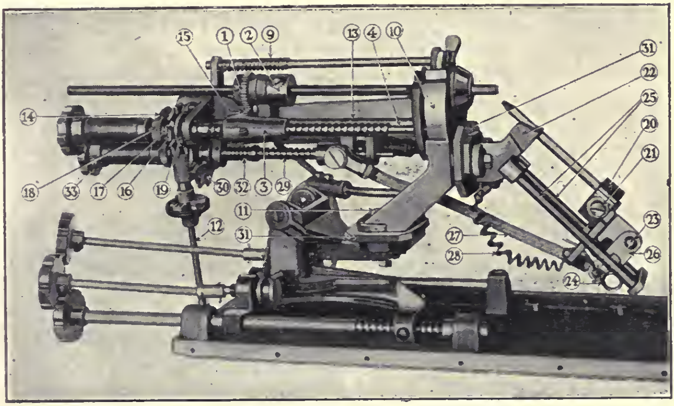


Figure 223-A.

Fig. 223-B is an illustration showing the view of the positive head through which the tip of the positive carbon 5 protrudes. Current carrying contact with the positive carbon is made through positive head 6 and contact tension "brush" 7. Contact tension brush 7 is pressed down on the carbon by finger clamp 8, which is held down by means of spring 9 Fig. 223-A.

This is a most excellent arrangement, in that it enables the projectionist to almost instantly remove contact tension brush 7 and thoroughly clean the contact surface. The importance of this is understood when we consider that good electrical contact can only be had between the carbon and the metal when the metal is perfectly clean.

To remove positive head 10, Fig. 223-A, it is only necessary to remove screw 11, Fig. 223-A. Positive head 10 rests in a cradle which allows the head to "float." This is important in that it enables the contact to adapt itself to any inaccuracy either in the circumference or in the straightness of the positive carbon, thus preventing tendency to arcing between the carbon and the metal.

The positive carbon has two movements. It is fed forward and is revolved. The latter motion is accomplished as follows: Shaft 12 connects to the mechanical arc control illustrated in Fig. 221, and described in the text Page 582. Shaft 12 revolves shaft 13 through the pair of bevel gears seen at 14, Fig. 223-A. This in turn drives gear 15 which in its turn drives gear 1, thus revolving the positive carbon.

The positive carbon is fed forward by means of a pin cam attached to shaft 13. This cam carries two pins which engage with and rotate star wheel 16.

Star wheel 16 is not attached rigidly to feed screw 4, but rides loosely thereon. It is clamped between shoulder 19 and a washer on the other side, by means of spring 17, the pres-

Figure 223-B.

sure of which is controlled by knurled thumb screw 18. Shoulder 19 is rigidly attached to feed screw 4. With this in mind you will readily understand that with spring 17 under sufficient pressure the rotating of star wheel 16 will also rotate feed screw 4 by reason of the friction between shoulder 19 and star wheel 16. This arrangement, which is nothing more or less than a friction clutch, enables the projectionist to rotate feed screw 4 by hand, and thus at any time feed the positive carbon independent of the carbon arc control. The arrangement is practical and excellent, though the hand-feed will of course work stiff since sufficient force must be exerted to overcome the friction of the clutch.

The negative carbon is held by clamp 20, which is tightened or loosened by means of set screw 21. This clamp is hinged at 23, the carrying lug of which, 26, rides on rods (two of them) 25. Spring 24 performs the office of pulling the entire clamp assemblage downward, thus causing the tip of the negative carbon to rest upon contact cooling plate guide 22 with considerable pressure. Current is carried to the negative carbon through conductor 27, which joins clamp 20, as shown. Copper strip 28 carries current to contact cooling plate guide so that the negative carbon actually receives current both through clamp 20 and guide 22.

The negative carbon is fed upward by means of feed screw 29, which is rotated by means of star wheel 30. The action is exactly similar to that of star wheel 16 which feeds the positive carbon forward. An examination of Fig. 223-A will, I think, show you how it works without further explanation. A clamping arrangement, or friction clutch exactly similar to the one already described enables the projectionist to feed the negative carbon by hand. You will note that the pin wheel which rotates star wheel 30 has only one pin, whereas the pin wheel which rotates star wheel 16 has two. This is to secure the proper ratio of feeding as between the positive and negative carbon. 31—31 is the insulating material.

The lamp is a decided departure in high intensity lamps in that it has the usual adjustments which enable the projectionist to raise, lower, or move the arc sideways, or to advance the whole lamp nearer to or farther away from the condenser.

IMPORTANT!—On negative feed screw 29 spring 32 is mounted. This performs an important function, in that the projectionist is enabled, by grasping negative feed wheel 33, to pull the negative carbon up into contact with the positive for the purpose of striking the arc. This action is accomplished by a quick, hard pull. Immediately upon releasing negative feed wheel 33, the negative carbon drops back into its proper position.

CAUTION.—It is important that when negative feed wheel 33 is pulled outward in order to strike the arc, it be released the instant contact between the two carbons is accomplished. In other words the **carbon tips must NOT be held in contact with each other.**

CARE OF LAMP.—The projectionist should remember that lamps of this type have several revolving parts and that these parts work in the comparatively high temperature of the lamphouse, to which is added a considerable amount of heat conducted directly through the metals of the lamp itself. It is therefore important that: (A) The lamp be kept scrupulously clean. (B) Feed screws 13 and 29, negative carrying rods 25, the carbon clamp screws and all moving parts of the lamp should have "Gradac" rubbed on them occasionally. Gradac may be obtained from any good automobile supply dealer.

It is absolutely essential that the contacts between the carbon and the metal, both in the positive head, in guide 22 and in clamp 20 be kept clean. This may best be accomplished by securing a rod of carborundum, household size, such as is used for sharpening kitchen knives. These rods are about 7/16 of an inch in diameter. They may be obtained from any hardware dealer at a cost of about ten cents. To clean the clamps run the carborundum through three or four times, with a twisting motion. This will clean and polish the metal, and insure good electrical contact. After cleaning the contacts it is important that all carbon dust and scale be blown out of the contact.

EXTRA PARTS.—An extra positive head 6, Fig. 223-B, an extra contact brush 7, Fig. 223-B, and an extra spring 24, Fig. 223-A, should be kept on hand.

IMPORTANT!!—Positive head 6 and carbon brush 7, Fig. 223-B, must conform to the size carbons used, in other words, **if you change the size of your carbons, you must also change these two parts, as well as washer 2, Fig. 223-A.** These parts may be had in two sizes to fit 7/16th inch carbons, which is used for 75 amperes and 13.5 millimeter which is used for anything above 80 amperes.

CAUTION.—Washer 2, Fig. 223-A, does not carry current. **It is neither necessary nor desirable that the set screw in washer 2 be tightened down solid. All it does is clamp the carbons with sufficient force to carry it forward against the friction of the positive head. If you tighten the set screw too tight you will very likely break the carbon, or crumble it at the point of contact with the screw.**

CAUTION.—The crater of the positive carbon should at no time come closer than one inch from the positive head. If you allow the crater to burn back too far you will blister the metal, and probably ruin the positive head. Be sure and maintain a distance of one inch, or even a trifle more.

ARC GAP.—The proper separation between the negative and positive is about one-half inch. You may be able to get a fairly good light with a ¼-inch gap or with a ¾-inch gap, but you will get a much better light by maintaining the proper arc length of about one-half inch. A less arc length than this gives too low, and a greater arc length gives too high an arc voltage.

CAUTION.—It is important for health reasons as well as for the purposes of ventilating the lamphouse, that the lamphouse be connected either to the vent flue or to the open air by means of a suitable pipe. Make no mistake, THIS IS IMPORTANT! Do not operate a high intensity lamp without your lamphouse connected either with a vent flue or with the open air.

NOTICE.—In event that something puts the mechanical arc feed out of commission, the lamp may be operated by means of a special handle attached to shaft 12. This handle is below the base of the lamp, outside the lamphouse and does not show in the illustration. Revolving it causes the lamp to function just the same as though it were fed by the mechanical arc feed.

CAUTION.—When operating a lamp of this type it is well to have hand bellows for the purpose of blowing out carbon dust after cleaning contacts; also for the purpose of blowing dust and dirt out of the lamphouse. **See Page 869.**

IMPORTANT NOTE.—Full description of other High Intensity Arc Lamps will be found under the heading "The High Intensity Arc," beginning on page 773.

The Mechanism

General Instructions Which Apply to All Projectors

MOTION picture projectors are very frequently sold to small town exhibitors who, in the very nature of things, are unable to employ competent projectionists, and who themselves have very little knowledge of mechanics. When a part wears or breaks they are at a loss as to the method of procedure necessary to remove same and replace it with a new part; also they are unable to make the necessary adjustments of the various parts of the projector properly.

In supplying amusement to what in the aggregate amounts to many millions of people who would otherwise be deprived of the pleasure of moving pictures, these men are doing a distinctly meritorious work. They are entitled to every bit of instruction it is possible to give them, including detailed instruction with regard to the projector mechanism, because any additional knowlege which enables them to project a better picture will add to the pleasure of all these millions of people who depend upon small town or village moving picture theatres for the only form of theatrical amusement they have.

Not only is this true, but it also is a matter of fact that even competent, experienced projectionists are offtimes at their wit's end, and commit very serious blunders by reason of the fact that but few projectionists, except those in very large cities, are able to obtain experience on all the different professional moving picture projectors. It is also quite true that even many projectionists in large cities lack expert knowledge.

We therefore have no apology of any kind whatsoever to make for supplying detailed instructions on projector mechanism. To omit them would not only be unfair to the industry as a whole, but also to the audiences who patronize moving picture theatres, and, moreover, to the projectionist himself. The claim that such instructions have a tendency to create projectionists has little weight. Even if it did the projectionist, important as is his function, is but one cog in the mechanism of the moving picture industry, and in such matters we must first look to the well-being of the industry as a whole.

There are certain instructions which apply to all projectors equally. We give them under the form of general instructions, in order to avoid consuming space by their repetition in the detailed instructions for each projector.

GENERAL INSTRUCTION NO. 1—LUBRICATION.— The modern projector is a rather expensive piece of mechanism. The purpose of oiling is to separate moving parts, and thus to reduce friction, abrasion and wear to the least possible minimum. Any oil will serve this purpose fairly well, provided enough of it be used, but in a projector mechanism the use of a minimum of oil is highly essential, because any excess will be thrown off by centrifugal force, get smeared around, and, besides making a dirty mess, will get on the films and do a very great amount of damage to screen results.

Oil that is too thin is objectionable for use on a projector, no matter what its lubricating properties may be, because it flies around and runs around too easily. Oil that is too heavy is objectionable because projector bearings are very closely fitted, and a heavy oil will not work through them fast enough, remembering that as the oil passes through a bearing it carries out with it any small parts of metal that have worn from the bearings, as well as foreign dirt which may have lodged there.

The selection of oil for use on a projector mechanism is therefore of the utmost importance, and as a rule, three different lubricants are essential: (a) a lubricating oil for the various bearings, (b) a lubricant suitable for use in the oil well of the intermittent movement, (c) a lubricant for the gears.

We are all familiar with the names of certain much advertised oils, such as "3-in-one." These oils are, in our opinion, without exception absolutely unfit for moving picture projector lubrication. Their use will, we are firmly convinced, shorten the life of a projector very greatly.

IMPORTANT RULE.—One rule with regard to projector lubrication is of huge importance. It should be rigidly adhered to by all projectionists.

Never, under any circumstances, use more than one drop of oil in any moving picture projector bearing.

Any more than one drop is very much worse than useless. One drop is ample for all purposes of lubrication in any bearing of a projector. Any excess over that amount will run out of the bearing and be thrown off, making a dirty mess, and, to some extent at least, very likely getting on the film.

In our previous books we have recommended a good grade of light dynamo oil for the lubrication of projector bearings. We see no reason for changing this recommendation. This oil can be procured, in bulk, from any dealer in oils at a very reasonable rate, but we would recommend that, where it is possible, it be purchased from the local electric power company, because they are obliged to use a high grade lubricant for their dynamos.

All, or nearly all, the various projector manufacturers themselves sell oil which they recommend for use on their projector. We can recommend these oils because, in the very nature of things, projector manufacturers would not select an oil for use on their projectors which would give other than good results.

The manufacturers are interested in seeing their projectors give good performance, and, knowing that adequate lubrication is absolutely essential to the satisfactory performance of any mechanism, naturally they will not recommend or sell anything but an oil suitable for use thereon. We therefore amend our former recommendation of dynamo oil to the extent of saying: **Use either a good light dynamo oil or the oil recommended by the maker of your projector.**

OIL WELL LUBRICANT.—The intermittent of the projector is subjected to exceedingly heavy service. Sixteen times every second the driving element strikes the driven element what amounts to a heavy, sliding blow, hence, unless it run in a high grade, suitable lubricant you may expect both these parts to wear very rapidly.

While we can recommend a heavy bodied, non-carbon oil, such as a very heavy dynamo oil, still in this particular thing **we would suggest that you implicitly follow the instructions of the projector manufacturer with regard to intermittent lubrication.** All, or nearly all, manufacturers of professional projectors have for sale a special lubricant which they recommend for use in the intermittent oil well. This lubricant has one very important peculiarity, viz.: it will not run out through the sprocket shaft bearing. It is a good lubricant for the purpose, and we recomend its use.

Never, under any circumstances, put graphite, or anything else except pure oil, or whatever is recommended by the projector manufacturer, in the intermittent oil well. Graphite is a high grade lubricant under some conditions, but it will injure or even ruin an intermittent movement, and may do it very quickly, too.

GEAR LUBRICATION.—A light oil, such as is used for the projector mechanism bearings, is not suitable for gear lubrication. Automobile cylinder oil, bicycle chain lubricant, automobile cup grease, or transmission grease, or a good grade of vaseline, is very much better. Beeswax also has been used by some, and tallow by others.

WASH OFF GEARS.—If the projector mechanism be of the uninclosed type, however, no matter what kind of lubricant is used it will collect dust and dirt constantly, which, uniting with the lubricant, forms a grinding paste. It is therefore advisable to thoroughly clean the gears of the projector mechanism at least once or twice a week. The most practical way is to have a shallow dish or pan constructed which will fit around one side of the mechanism base, under the gears. With the pan in place, while you run the projector very slowly, flood the gears with kerosene or gasoline from an ordinary squirt can. It, of course, is possible to remove the mechanism from the stand and immerse the whole thing in kerosone or gasoline, giving the crank several turns while the mechanism is so immersed. This thoroughly cleanses both the gears and the bearings, but is, we think, more trouble than it is worth. If it be done, first be sure the intermittent oil well opening is closed tightly.

WASH OUT OIL WELL.—The oil well should be emptied at the end of one hundred and fifty hours' run and filled with fresh lubricant.

From continued use oil becomes "poor." In other words, its lubricating powers are lessened through continued use. After emptying the oil well it is a good plan to wash it out with kerosene, being sure, however, to remove every bit of the kerosene, else it will reduce the lubricating quality of the new oil, and make it more apt to run out through the bearings.

GENERAL INSTRUCTION NO. 2.—Where the old style friction take-up is used it is of utmost importance that the take-up tension be set just barely tight enough to take up the entire reel. Any tension in excess of this is not only bad, but it is **very** bad, particularly if the old style 1½ inch reel hub be used. A moment's study of this matter will convince you of its importance. Throughout the entire process of re-winding, the take-up friction will exert precisely the same amount of pull on the spindle which carries the take-up reel. When the film first begins to wind on the hub of the lower reel, the diameter of the film roll will be less than 2 inches, if an old type reel be used, therefore the pull on the film will be very heavy. As the diameter of the film roll increases, however, the pull on the film decreases, until when the reel is full it will be very slight.

In other words, since the pull of the take-up is constant, and must be sufficient to revolve the reel when it is full, the actual pull exerted on the film at the beginning of the process of re-wind, is very many times greater than it is at the end. This means that not only is the film wound entirely too tightly at the beginning, and too loosely at the end, but also that during the beginning of the process of re-winding the pull on the film is so heavy that if there is excess tension it is quite possible the sprocket holes may be strained, or even broken, since the pull is against the lower sprocket of the projector. It is even possible, and does often happen, that the film is pulled over the lower sprocket, and the lower loop is thus lost, though ordinarily this only takes place when a bad splice comes through.

Excess tension also is apt to pull weak splices in two. It is in every way detrimental, therefore the projectionist should use every precaution to have his take-up tension set exactly right, and "exactly right" is that tension which will no more than insure completion of the process of re-winding. Of late there have been some very excellent devices invented which equalize the take-up pull throughout the process of rewinding. Also the split pulley friction take-up has been to a very great extent improved by increasing its diameter.

GENERAL INSTRUCTION NO. 3—DIRTY SPROCKETS. —It is of the utmost importance that the sprockets of the projector be kept perfectly clean. This is important for all sprockets, but particularly for the intermittent, because any dirt accumulating on the face of the intermittent sprocket will cause unsteadiness of the picture on the screen. The best method of cleaning sprockets is as follows: Procure a rather stiff bristle toothbrush, and either a wide-mouthed bottle or a small tin can with a cover. If the bottle be used, drill a hole through its cork and shove the handle of the toothbrush through, so that when the cork is in the bottle the brush will reach almost to the bottom. If a can is used cut a hole in the lid large enough to admit the brush.

Partly fill the bottle, or can, with kerosone, and once a day (oftener if necessary) examine the sprockets closely, and if there is the least bit of gum or dirt on the face of any of them scrub it off with the toothbrush wet with kerosene.

Examine your sprockets carefully at least once a day, making certain they are perfectly clean. Dirt on the intermittent sprocket will cause the picture to jump, not sometimes, but always, while dirt on the upper or lower sprocket may cause the losing of one of the loops.

It is an astonishing thing that some projectionists do not grasp the seemingly self-evident fact that the face of the intermittent sprocket, or any other sprocket for that matter, must be kept perfectly clean. We have known of a projector mechanism shipped a distance of two thousand miles to the factory the complaint being that "the picture jumped terribly." On examination the face of the intermittent sprocket was found to be covered with gum and dirt. This was cleaned off in less than a minute, and the machine tried out, with the result that the picture was rock steady. It seems unbelievable that a man with no more intelligence than this would indicate would undertake to project photoplays, and reproduce upon the screen the work of some of the best artists in the world. Imagine, if you can, sending a projector more than two thousand miles merely to have the dirt cleaned off the face of its intermittent sprocket, a thing the projectionist himself could have done in a minute with the aid of a little kerosene and a toothbrush.

GENERAL INSTRUCTION NO. 4—SPROCKETS IN LINE.—It is important that the sprockets of your projector be in perfect line with each other and with the aperture. With modern projectors there is little possibility of getting the sprockets out of line. It is, however, well to test the matter when a new sprocket is installed. I cannot give definite instructions as to how to test the lining cf the sprockets, since they will vary with different makes of projector. The meaning will, however, be understood by examining Fig. 224, in which dotted line is presumed to be exactly central sidewise in the aperture and the teeth on each side of each sprocket must be equidistant from the line. This may be roughly tested, so far as the intermittent and upper sprockets be concerned, as follows: Thread a piece of new film into the projector, engaging it with the teeth of the upper and intermittent sprockets, closing the idlers. Turn the fly-wheel backwards until the film is stretched tightly. If the upper and intermittent sprockets and the aperture are in the line with each other, that fact will be evidenced by the film-edge being out of line with the tracks on the aperture plate, or the aperture being out of center in the film. If the film seems to bear equally on both edges of both sprockets, and the aperture plate tracks are not straight with the film, it would indicate the probability that the aperture plate itself is out of true. In some projectors this may be easily remedied; in others the aperture plate cannot possibly be out of true, and the indication would be that both the upper and intermittent sprockets are too far over to one side. Before making this test you should be sure the intermittent sprocket shaft is in exact alignment with the cam shaft, because if one end of the intermittent shaft be high or low, the intermittent sprocket will not be square with the film. This condition is not possible except on projectors in which either end of the intermittent sprocket shaft may be raised or lowered independently of the other end.

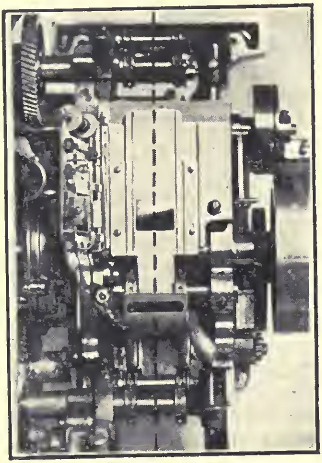


Figure 224.

GENERAL INSTRUCTION NO. 5—ADJUSTMENT OF INTERMITTENT MOVEMENT.—When the intermittent movement is on the "lock" its adjustment should be such that there will be very little circumferential movement in the intermittent sprocket, but care must be exercised that the adjustment be not made too close or else there will be undue and unnecessary friction of the parts. These adjustments are usually made when the projector is cold, and it must be remembered that under the influence of the heat of the spot, all the parts expand more or less, and that fact must be taken into consideration. If the adjustment is made close enough so that you can feel the intermittent sprocket move just the least little bit when you try to rock it with your finger, it will be correct.

A very little circumferential play in the intermittent sprocket does no harm, in fact it is necessary; excessive motion will be harmful in several ways.

Do not attempt to adjust the intermittent as above if the cam, the star or the intermittent shaft bearings are appreciably worn.

SPARE INTERMITTENT MOVEMENT.—We strongly advise the purchase of a spare, complete intermittent movement, assembled all ready to place in the projector. With some projectors the removal of an old intermittent movement and installation of a new one takes quite a bit of time. With others an old movement can be removed and a new one inserted, all ready to project the picture, in a few moments. In order to have steadiness of the picture on the screen it is essential that the intermittent movement of the projector be in about as nearly perfect mechanical condition as any mechanical thing can be. Our reason for advising the purchase of a spare intermittent (one spare for a two-projector installation will serve) is that the repair and adjustment of so delicate and essential a part of the mechanism can usually be better taken care of at the factory or service station of its manufacturer than anywhere else. Having a spare intermittent, when the intermittent of one of the projectors is in need of attention it can be pulled out, the new one put in its place and the old one sent to the factory or service station by insured parcel post, at an expense of a few cents, where it can be put into first class condition and returned. The replacement of an intermittent sprocket, star or cam, is a very delicate operation, and one which should be done at the factory or service station only.

This is particularly true in the case of the cam and star, or cam and diamond in the case of the Power's projector, because it is very difficult, not to say impossible, for the projectionist to fit these parts properly.

Never attempt to put in a new star and try to make it run with an old cam, or vice versa. If either a new cam or star is to be put in, we would by all means advise that the part it is to work with be renewed also, and that new brushings be installed as well.

It is possible for the projectionist, by intelligent and very careful work, to replace a worm intermittent sprocket. For this purpose there is a press made by V. R. Shaw, Motion Picture Projectionist, Marian, Indiana, which not only presses out the pins, but presses the shaft out of the sprocket. It is not an expensive tool, and we commend it to the favorable consideration of projectionists, though whether it will be placed in the hands of supply dealers or not we cannot, at this time, say. Another excellent plan is to get a sprocket anvil, illustrated in Fig. 225, which may be had from the E. E. Fulton Company, 3208 Carroll Avenue, Chicago, Illinois. With this it is possible to drive sprocket pins out without injuring either the pins or the sprocket. Such an anvil can be made. The drawing is full size. Never lay the face of a sprocket down on a bench and try to drive the pins out. Support the **hub** of the sprocket instead. After a sprocket has been on a shaft for some time it may stick pretty tight. The shaft, however, may be driven out without danger of injury to either it or the sprocket as follows: Open a vise about an inch. Across its jaws lay two short pieces of hardwood board, which for some projectors must not be more than ¼ of an inch thick. In the edge of one cut a notch large enough to admit the sprocket shaft. Place the sprocket with its lower edge resting on the boards, the star end hanging down between the jaws of the vise. Using a short piece of No. 6 copper wire for a punch, gently tap on the end of the shaft and drive it out, being very certain it does not fall when released.

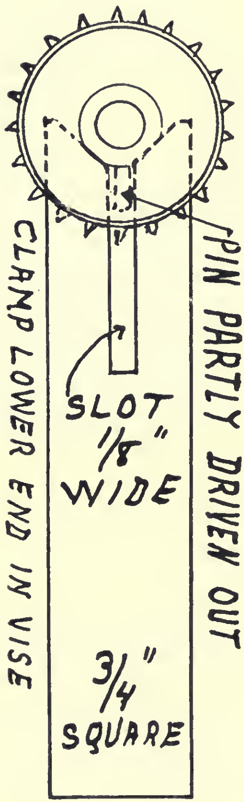


Figure 225.

When the old sprocket is removed, clean the shaft thoroughly, being certain there are no burs or sharp edges on pin holes. Wipe off perfectly clean and lubricate with good oil, after which push the new sprocket on with a twisting movement. If it sticks when partly on, pull off, clean shaft, re-lubricate and repeat the twisting movement as you push sprocket on again. These parts must and do fit with great accuracy, and the twisting is to grind down any slight oversize of shaft.

It may or may not take several removals and re-lubrications, but if persisted in the sprocket will finally be in place, and will fit accurately.

CAUTION.—Intermittent sprockets are pinned on the shaft with taper pins, the small end of which should be marked with a center punch mark. If it is not thus marked, and you cannot tell which is the small end with your naked eye, you can by using a condenser lens for a magnifying glass.

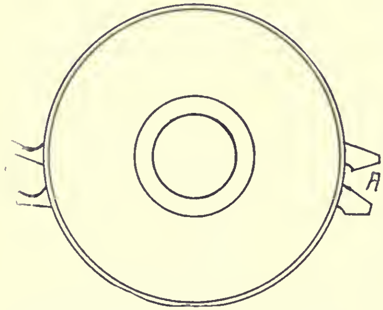
CAUTION.—Don't hammer on the small end of a taper pin with a steel hammer. Either use a punch, or if the end of the pin protrudes appreciably, lay a piece of copper on the end of the pin and start it by tapping on the copper.

CAUTION.—In replacing the sprocket be sure you get the big end of the hole in the sprocket hub opposite the big end of the hole in the shaft, and don't drive the pins in too tightly. Just set them up snug. If you drive too hard you will not only make it either difficult or impossible to remove them when the time for their removal comes, but you may spring the metal of the sprocket or shaft, and thus force the whole thing out of true. Remember that the taper of the pin is very slight, hence it is a very powerful wedge.

GENERAL INSTRUCTION NO. 6—END PLAY OF INTERMITTENT SPROCKET.—There must be no appreciable end motion of the intermittent sprocket. If there is it may produce side motion of the picture on the screen. In most modern projectors it is extremely unlikely that such end motion will develop, but if it does it must be eliminated. In some instances side play is due to the holes in the sprocket hub, in which are the pins holding the sprocket to the shaft, being worn. If there is end motion and you can find no other probable cause, remove one of the pins and examine the hole it came out of under a magnifying glass. A condenser lens will probably serve. If the hole is out of round, then the holes must be reamed out and the new pins put in. The Simplex service stations will provide a suitable reamer.

We presume other manufacturers will do the same. Be careful to remove no more than sufficient metal to make the holes perfectly round. The new pins will, of course, go in further than did the old ones, but that is quite all right.

GENERAL INSTRUCTION NO. 7—WORN SPROCKET TEETH.—Never continue to use an intermittent sprocket if its teeth have become appreciably worn, because such a sprocket is not only very likely to produce unsteadiness of the picture on the screen, but will inevitably do serious injury to the working edges of the sprocket holes, thus making it impossible under any circumstances to thereafter project a perfectly steady picture with the film that has been thus abused.



Enlarged Sprocket, Showing Hooked and Undercut Teeth.

Figure 226.

EXAMINE TEETH.—Once every week the projectionist should, using a condenser lens for a magnifying glass, carefully examine the wearing surface of the intermittent sprocket teeth. If he finds any indication of undercut, such as is shown on edges of tooth A, Fig. 226, or if he finds any indication of "hooking" of the tooth, as per tooth B, Fig. 226, the sprocket should be immediately replaced with a new one. It is not advisable to attempt to turn an intermittent sprocket around so as to use the other side of the teeth.

Worn intermittent sprocket teeth, besides setting up the probability of inducing unsteadiness of the picture, and injuring the edge of the sprocket holes of the film, have a decided tendency to cause the teeth to climb the sprocket holes, thus losing one of the loops.

The intermittent sprocket teeth do all the work of pulling down the film against the braking action of the tension shoes, hence are subject to very heavy wear. True, they are or should be glass hard, but the friction between the teeth and the film is heavy, and is confined to a very small surface only, hence it is possible the teeth may show signs of wear in a comparatively short time, **particularly if the pressure of the tension shoes be excessive.**

GENERAL INSTRUCTION NO. 8—GATE IDLERS.—Top idler on the gate, or whatever takes it place, is for the purpose of holding the film central over the aperture, and to help in preventing side motion of the film. Some of these guides have the possibility of adjustment, while in others the position is fixed, and cannot be altered. If there is an adjustment, the guides should always be kept set close enough to prevent any side motion in the film, but not close enough to cause any binding. In some of the older type projectors it is possible to get this adjustment far enough to one side that the sprocket holes will show on the screen. We believe this, however, is not possible with any modern professional projector.

GENERAL INSTRUCTION NO. 9—GATE TENSION SPRING ADJUSTMENT.—There is no one thing in connection with the work of the projectionist which receives less intelligent attention than the adjustment of the gate tension, or in other words the amount of pressure exerted by the tension shoes on the film at the aperture.

It is of course understood that by means of the upper and lower loops the strip of film between them is detached from the rest of the film, to the extent that it may stop and start while the rest of the film runs continuously.

The office of tension shoes (in the old types of projector there were no shoes. The flexible tension spring bore directly on the film) is twofold. First, to stop the film when the intermittent sprocket stops. Second, to hold the film perfectly flat over the aperture during its period of rest. If the tension be too weak there will be "over-shooting," which means that the film will not be stopped the exact instant the motion of the intermittent sprocket ceases, but, due to momentum, will continue slightly after the sprocket stops and possibly in varying amounts.

The effect of too much tension is (A) heavy and unnecessary wear on the mechanism of the entire intermittent movement, but particularly on the wearing surface of the intermittent sprocket teeth, (B) heavy and unnecessary wear on the delicate edges of the sprocket holes in the film, which is bad in any event, and will be increasingly injurious if the sprocket teeth are in any degree under-cut or hooked It is even possible, particularly when combined with high speed of projection, that the strain will be sufficient to split or crack the film at the corners of the sprocket holes. Once a film has been subjected to abuse of this kind it will thereafter be forever impossible to produce a rock steady picture when using that film.

Summed up, this means that the tension cannot be too slack without producing an injurious effect on the screen, and it cannot be too tight without injuring both the projector and the film itself.

HOW TO SET TENSION.—Every projector should have a tension adjustment in substantial, accessible form. The screw by means of which this adjustment is made, besides being accessible, should be located away from the heat of the spot. Adjustment of the tension cannot be made when there is an audience in the theatre. In former editions of this book instructions for making this adjustment were given which there is no reason to in any degree change or modify. They were as follows:

Thread into the projector a film, the sprocket holes of which are in good condition. Run the projector at a speed about 10 revolutions of the crank shaft per minute faster than your highest speed of projection will be. Continue this speed steadily while you so adjust the tension adjustment that the picture just begins to crawl up on the screen, which means that overshooting has commenced.

This is as accurate an adjustment as it is possible to make; also it is one which anyone can apply, always providing there is a tension adjustment on your projector. If there is no tension adjustment, then it will be necessary to bend the tension springs until the desired pressure is had. It is no easy job to do this, but it is nevertheless up to the projectionist to do it, and **any man who has not sufficient regard for the projector and films placed in his charge to at least safeguard them to the extent of properly adjusting the tension is unfit to have charge of a projection room.**

GENERAL INSTRUCTION NO. 10—EMULSION DEPOSIT.—First run films are frequently sent out with the emulsion so soft that it has a strong tendency to deposit on the face of the tension shoes, **particularly if the tension be excessive.** Projectionists are obliged to run these films, and they experience a great deal of trouble by reason of the deposit. The tendency to deposit may be increased by the too liberal use of cement in making splices. The emulsion, or a mixture of emulsion and cement forms a very hard, unyielding mass on the polished surface of the tension shoes, which, besides causing the tension shoes to jump and clatter, is likely to injure the film itself more or less seriously.

When using a first run film, the surface of the tension shoes and the aperture plate track should be carefully examined after each reel, (excess of film cement will sometimes deposit on the tracks of the aperture plate) and any deposit found thereon must be carefully removed.

BEST WAY TO REMOVE DEPOSIT.—The deposit may be removed by scraping it off with the edge of a silver coin, or by the use of some other soft metal, but the best way is to use a wet cloth. Water softens the emulsion instantly, therefore the deposit may be quickly washed off without any possibility of injury to the polished parts.

CAUTION.—Never use a knife blade, screw driver or other hard steel instrument to scrape deposit off the tension shoes or aperture plate tracks, because by so doing you will scratch the polished surface and thus increase the tendency to deposit.

Many plans have been tried for the elimination of this trouble, but the only really practical thing is the lubrication of the film track. See Figs. 77-A, Page 271, and 77-B, Page 273.

It is possible to make a fairly effective film track lubricator as per Fig. 77-C, Page 274.

It is even possible to reduce the trouble somewhat by rubbing the tension shoes with the end of a tallow candle before threading the projector, or by holding a tallow candle lightly against the teeth of the upper sprocket occasionally for a few seconds while the film is running.

GENERAL INSTRUCTION NO. 11—WORN APERTURE PLATE TRACKS.—In instruction number 9, we said that one of the offices of the gate tension is to hold the film perfectly flat over the aperture. This, of course, cannot be done unless the surfaces of the aperture plate tracks be themselves true and level; it therefore follows that excessive wear of the aperture plate tracks may, and probably will, cause a buckling of the film over the aperture, and an out-of-focus effect on the screen. By this we do not wish to be understood as meaning that buckling of the film over the aperture is always due to this cause, but while it may be induced by other causes, such as old, shrunken film, worn aperture plate tracks are pretty sure to produce the trouble. Buckling of the film over the aperature will cause an out of focus effect or an "in and out" of focus effect.

The projectionist should carefully examine his aperture plate tracks, with reasonable frequency. and should renew them as soon as they show any appreciable unevenness of the surface.

GENERAL INSTRUCTION NO. 12—SPROCKET IDLERS. —It is essential to proper performance of sprocket idlers that the idler set equidistant from the face of the sprocket at both ends of the sprocket, and that the distance of the idler from the face of the sprocket be a trifle more than the thickness of a film. If the sprocket idler be not carefully and accurately set as per the foregoing, there is likely to be more or less trouble, particularly at the lower sprocket. The losing of the lower loop, while not of course necessarily chargeable to improper setting of the lower sprocket idler, nevertheless is very frequently due to that cause, particularly if there is excessive take-up tension. If the lower sprocket idler be out of line with the sprocket, or too far away from the sprocket, or close enough to the sprocket to pinch the film, there will probably be trouble through losing of the lower loop.

Never allow your sprocket idler to "ride the film"—that is to say, to bear on it with any pressure. This is particularly bad if the pressure be greater on one side of the sprocket than on the other. Under that condition, the film is likely to climb the sprocket at the first bad splice.

Examine your sprocket idlers frequently, and make sure that they are turning freely. If they do not they will soon develop a flat spot, which sooner or later means trouble. All professional projectors have an adjustment by means of which the projectionist may determine the distance of the idlers from the face of the sprocket. A fairly good plan is to place two thicknessess of film on the sprocket, and then adjust the idlers so they rest on the film; with this adjustment and only one thickness of film, the idler should be about the right distance from the sprocket.

GENERAL INSTRUCTION NO. 13—LINING CAM SHAFT.—When using a projector in which the adjustment between the star and cam is accomplished by turning an intermittent sprocket shaft bearing at either end, great care should be taken that the intermittent sprocket and the cam shaft are kept in perfect alignment with each other. The position of the cam shaft is not adjustable, but the sprocket shaft is raised or lowered by turning the bearing bushings, and it is possible, by turning one bushing more than the other, to get the sprocket shaft lower on one end than the other, under which condition the sprocket will not be square with the film, and the teeth on one side of the intermittent sprocket will have to do most of the work in pulling the film down. This matter should be watched very closely when an adjustment is made.

GENERAL INSTRUCTION NO. 14—MAGAZINES IN LINE.—With modern projectors the position of the upper and lower magazines are fixed, and they cannot be located wrongly. With some of the older types, however, it is quite possible to get the magazine out of line sidewise with the sprockets, and this should be guarded against, because a magazine out of line is likely to cause a great deal of trouble, in several different ways. If the lower magazine is out of line, the take-up will pull the film sidewise, which will create an added tendency to lose the lower loop. If it be the upper magazine that is out of line, the film will not approach the upper sprocket squarely, which may cause trouble, and in any event it will rub against the metal of the fire trap with possible damage to the film itself, and certain damage to the trap.

GENERAL INSTRUCTION NO. 15—PROJECTION ROOM REELS.—We very strongly recommend that the projection room have a full complement of reels, and that the exchange reels be used only in the upper magazine for the first run of the film after it is received, and in the lower magazine for the the last run of the film before shipment.

THE CONDITION OF REELS SENT OUT BY EXCHANGES IS, ALL TOO OFTEN, NOTHING SHORT OF AN OUTRAGE.

They are more often than not a cheap, flimsy affair, with a hub and spring clip in more or less wretched condition, with their sides bent and wobbly, and very frequently they have sharp edges of metal caused by the punchings of the reel sides when they are made, which to a greater or less extent injures the film.

Only projection room reels should be used for projection, and they should be kept in first class condition. Use of reels in bad condition causes an enormous amount of damage to films, both in rewinding and in projecting. Reel sides very often rub on the magazine side, thus setting up braking action, which, under some conditions, will pull the film in two. See Page 322.

Theatre managers will do well to understand the simple fact that all unnecessary damage done to films while in their own or any other theatre, becomes, of necessity, part of the overhead expense in film distribution. If, through carelessness in handling films on bad reels, etc., a heavy decrease in the life of the film is caused, then whatever the damage is, it must, and inevitably will be added to the film rentals. We venture the assertion that if theatre managers used a little common sense, and insisted that the films be handled carefully, and on reels that are in good condition, and that rewinding be done at the rate of six or seven minutes to the reel, instead of one or two minutes, film rentals would within a short time be reduced in a very noticeable amount.

GENERAL INSTRUCTION NO. 16—UPPER MAGAZINE TENSION.—In professional projectors there is usually some sort of tension device in the upper magazine, the purpose of which is to prevent the reel from revolving too freely. It is important that this device be so designed that it will not catch on loose screws or reel hubs, and that the tension be of sufficient amount to just barely keep the film taut at all times, and stop the reel instantly when the projector stops. The importance of this latter will be realized when we consider that if the reel revolves too freely, and the projector be stopped when the upper reel is three-quarters or more emptied, and the reel continues to make one or two revolutions after the projector has stopped, thus unwinding considerable slack film, when the projector is started it is likely to come up to normal speed before it takes up all the slack film, whereupon the upper reel will be subjected to a sharp jerk, which may pull a splice in two, rip out sprocket holes and lose the upper loop, or even pull the film itself in two.

GENERAL INSTRUCTION NO. 17—FILING THE APERTURE.—It is sometimes necessary that the form of the projector aperture be changed, in order to parallel the sides of the screen image when there is a pitch in the projection. You will find directions for doing this on Page 257.

GENERAL INSTRUCTION NO. 18.—The Standard aperture now in use and approved by the Society of Motion Picture Engineers, is .6795 (87/128) of an inch high by .9062 (29/32) of an inch wide.

GENERAL INSTRUCTION NO. 19—MAGNETIZED SCREW DRIVER.—The projectionist will find a strongly magnetized screw driver a great convenience, particularly when handling small machine screws, since they may be removed and inserted without danger of dropping them.

GENERAL INSTRUCTION NO. 20—THREADING THE PROJECTOR.—All projectors thread precisely alike, so far as the operating principle is concerned.

There are differences in the mechanical application of the principle but the principle itself is always the same. The film comes down out of the upper magazine through a fire-trap,

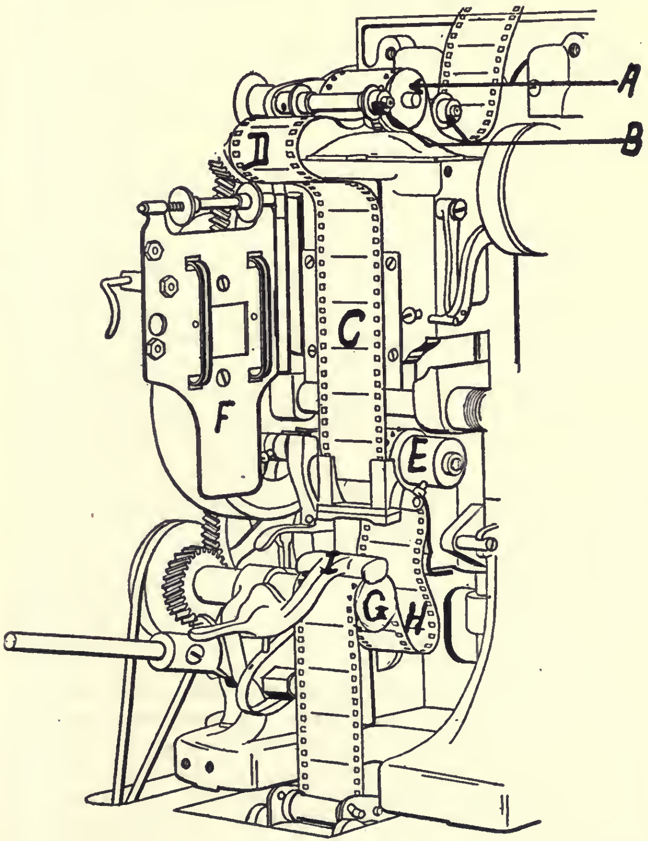


Figure 227.

engages with upper sprocket A, Fig. 227, and is clamped thereby to one or more idler rollers, B. The film may pass over the upper sprocket as is shown in Fig. 227, or it may pass under the sprocket. Having been attached to upper sprocket A it is carried down over the aperture, as shown at C, with sufficient slack film to form upper loop D. The film is then engaged with intermittent sprocket E, and is locked thereto by the idler, which may be a roller or may be a shoe, after which the gate F is closed and locked shut. The film is now engaged with lower sprocket G, Fig. 227, sufficient slack film being left to form lower loop H, Fig. 227. The film is locked to lower sprocket G by means of idler I, after which it is carried down through the fire trap into the lower magazine and attached to the take-up reel. Upper and lower loops D and H must have sufficient slack film so that when the intermittent acts the film between the upper sprocket and the top of the gate, and between the intermittent sprocket and the lower sprocket, will not be pulled tight. The reason for these loops is that whereas upper sprocket A runs continuously, pulling the film out of the upper magazine and feeding it to the intermittent, and lower sprocket G runs continuously, taking the film away from the intermittent sprocket and feeding it into the lower magazine, sprocket E only acts intermittently, so that the strip of film between the top of the gate and the intermittent sprocket is standing still about four-fifths of the time, and moving at high speed the rest of the time, its high speed while in movement exactly equalling the total travel of the rest of the film. In other words, while upper sprocket A feeds three-quarters of an inch of film in a given time, which we will assume to be 5/80 of a second, the film between the upper end of the gate and the inmittent sprocket moves exactly three-quarters of an inch in 1/80 of that time, standing still 4/80 of the time. The offices of the upper and lower loops are to enable the constantly running film above and below to join with the intermittently running film over the aperture.

GENERAL INSTRUCTION NO. 21—THREAD IN FRAME. —Modern practice demands that the film be threaded in frame. By this it is meant that when threading the projector the projectionist must so place the film that one whole photograph will register exactly over the aperture, neither the upper or lower frame line being visible. This can be accomplished in several ways. The projectionist may look through the lens while placing the film, or he may hold a lamp in front of the lens and look through the other way. At least one projector manufacturer, the Power's, places a small battery lamp inside the mechanism, which may be temporarily lighted while framing.

No matter what plan be adopted for accomplishing the purpose, however, the picture should never be projected to the screen out of frame. Such work is crude in the extreme, and brands the projectionist as a very slip-shod, careless workman, except possibly in one projector installation where threading must be done in the absolute minimum of time.

GENERAL INSTRUCTION NO. 22—REVOLVING SHUTTER.—The revolving shutter is an extremely important and integral part of the optics of the projector. Its function is to close the lens, or, in other words, to cut off the light from the screen during the time the intermittent movement is acting and moving the film over the aperture.

It is absolutely essential to intelligent work that the projectionist have a complete understanding of all those various things relating to and connected with the revolving shutter.

To begin at the beginning, there is no such thing as a "moving picture," or a "motion picture." What we term moving or motion pictures, is really nothing more or less than the display of a series of snapshot photographs, taken at the rate of sixteen or more per second, and displayed to us so rapidly that one photograph blends into the next, thus forming the optical illusion of motion.

Beginning at a frame line between two pictures, measure one foot of film, and you will find thereon precisely sixteen complete pictures. Except in the matter of size these pictures in no way differ from ordinary snapshot photographs. They are presumed to be taken at the rate of sixteen per second, but as a matter of fact in modern practice the speed of taking very frequently exceeds this considerably. As the film passes through the projector these photographs are, by means of the intermittent mechanism, successively posed over the aperture, and while so posed are projected, one after the other, to the screen. The purpose of the intermittent movement of the projector is to pull the film down across the aperture precisely three-quarters of an inch, and to leave it over the aperture for an infinitesimal period of time. At the rate of sixty feet of film per minute, the time each picture remains over the aperture is one-sixteenth of a second, less the time it requires to move the film down, which ordinarily, is about one-fifth of one-sixteenth of a second, or 1/80 of a second. We may therefore say that at the rate of sixty feet per minute, 4/80 of a second is consumed by the actual projection of the picture, and 1/80 of a second is consumed in the removal of one photograph and the substitution of the next —in the pulling down of the film.

WHY THE LENS MUST BE CLOSED.—If, however, the change of photographs over the aperture be made with the light projected constantly to the screen, there will be streaks of white up and down across its surface. The reason of this is as follows: White makes a greater impression on the eye than do colors of less brilliancy. Suppose we project a moving picture to the screen without any revolving shutter—with the light projected constantly. Suppose in this scene there is a man in evening dress, with a broad expanse of white shirt front. The dark colors of the evening dress make little impression on the eye, but the dazzling white of the shirt front makes a very great impression, and as the film moves and the figure of the man in one photograph is substituted for the figure of the man in the next, as the figure of the man in the first photograph is jerked down out of the way the eye will see and follow the brilliant whiteness of the shirt, though it will not see and follow the darker clothing. Also, as the other figure comes into view the eye will quickly catch the white of the shirt, and not see the dark clothes until the figure comes to rest. We would therefore have a white streak across the screen. These white streaks are technically known as "travel ghost."

Due to this phenomenon, it is necessary that the lens be closed during the time the intermittent movement is in action and the film moving, and this is the function performed by the revolving shutter.

The revolving shutter of a projector (except in the case of the one and one-and-a-half-to-one shutter, the action of which will be explained further on) revolves exactly once to every complete cycle of the intermittent movement. If a certain edge of the master blade of the shutter occupies a certain position with relation to the lens when the intermittent begins to act, it will occupy precisely the same position the next time the intermittent begins to act, having meanwhile made one complete revolution.

Without any film in the projector, open the gate, block the automatic fire shutter up and project the white light to the screen while you run the projector **very** slowly. You will observe that during the time the intermittent sprocket is in motion the master blade of the revolving shutter cuts off all the light from the screen. You will also observe that, according to whether you have a two-wing or a three-wing shutter, all the light is cut off from the screen two or three times during each complete cycle of the intermittent, or during each revolution of the shutter.

In projection, what we therefore have on the screen is a succession of flashes of more or less brilliant light, and a succession of almost equal periods of time when no light from the lens reaches the screen.

After running very slowly, as above directed, gradually increase the speed of the projector and you will find that when you get up to normal projection speed there will be an **apparently** uninterrupted screen illumination.

WHY MORE THAN ONE BLADE.—What we call "flicker" is the visibility of the period during which the screen is dark. The revolving shutters of all motion picture projectors have more than one blade. The reason for this is that, since light interruptions must be at the rate of 36 or more per second in order to render them invisible, the one-blade shutter would not be practical, because the light interruptions would come too far apart. As already explained, in motion picture projection the screen is alternately more or less brilliantly lighted and totally dark, insofar as light from the lens is concerned.

FLICKER.—The human eye is a peculiar instrument. It will transmit to the brain, as separate impressions, a certain number of impressions per second. Beyond that number, the impressions become merged into each other, so that the effect is that of continuity. This involves what is termed "persistence of vision," which is the peculiarity of the eye which makes the illusion of "moving pictures" possible. If the flashes of light and darkness come too far apart, or if they be disproportionate to one another, then the eye will perceive them. Under this condition persistence of vision operates incompletely, and instead of the illusion of even, steady illumination, the recurring flashes of light and darkness will be perceived in the form of what is termed "flicker." Flicker is a very serious matter indeed, in that it causes eye strain exactly in proportion to its amount. If excessive the strain on the eyes is very great and very highly injurious. Experience has taught that with a low illumination value, such as is represented by an ordinary cloth screen and an arc lamp using 25 amperes, the rate of interruptions of the light may be as low as 36 per second without flicker being objectionably visible. With a more brilliant illumination, however, such as is had with a brilliant screen surface and 60 or more amperes of current, we find it is necessary to increase the interruptions to between 55 and 60 per second in order to render them invisible, or in other words to obtain the effect of even, continuous screen illumination.

MASTER BLADE.—The blade which cuts the light from the screen while the intermittent sprocket is moving is variously called the "master" blade, "working" blade, "main" blade and the "interruptor" blade. We have selected **master blade** as the most appropriate term. In addition, the shutter has one or more additional blades, commonly termed "flicker" blades, the purpose of which has already been described.

The function of the master blade is to close the lens while the intermittent movement is in action. When the intermittent sprocket starts to move the master blade of the shutter comes in front of the lens and entirely shuts off the light from the screen, passing from in front of the lens and permitting the passage of the light to the screen the instant the intermittent sprocket comes to rest. From this we see that, in theory, the shutter must be so set or "timed" that its master blade will cover the lens, and shut off the light from the screen at the exact instant the intermittent begins to move, and uncover the lens at the exact instant the intermittent sprocket comes to rest. This, however, is to some extent modified. As a matter of fact the lens need be only about three-quarters closed when the intermittent sprocket begins to move, and may still be slightly open when the intermittent movement ceases. This is because of the fact that, with the lens three-quarters closed, the light on the screen is very dim, and the impression on the eye therefore diminished to a point where the movement of the picture over the aperture cannot be perceived. If, however, the timing of the shutter be such that the lens is open too much, either when the film starts to move or is coming to rest, travel ghost will result.

SHUTTER BLADE WIDTH.—What may be termed the optical balance of the revolving shutter has directly to do with the width of the shutter blades with relation to each other, and with relation to the light openings. It is a well established fact that a three-winged shutter having three blades of equal width with each other, and of equal width with the light openings, produces the best effect in that a flickerless picture can be had at a lower speed of projection than with any other available shutter.

A shutter of this kind cannot be used except under certain circumstances which will be explained under "intermittent speed and the shutter." It has been very thoroughly demononstrated that a three-wing shutter with the flicker blades of different width than the master blade, and with the light openings of different widths, produces an excellent effect, but this unbalancing may only be done in a certain prescribed way, one feature of which is that on either side of the master blade there shall be a comparatively wide opening, and between the two flicker blades an opening of relatively narrow width.

INTERMITTENT SPEED AND ITS EFFECT ON THE SHUTTER.—To the uninitiated it may seem a very simple matter to have a 50-50 shutter, i.e., a shutter in which all blades are of equal width with each other and with the openings, but as a matter of fact, it is not. As has already been pointed out, the master blade of the shutter must be wide enough to cover about three-quarters of the lens opening, or to cut about three-quarters of the light beam when the intermittent sprocket starts to move, and still have about three-quarters of the beam covered when it comes to rest. Remembering that the shutter revolves once to every cycle of movement of the intermittent, it will be seen that the longer the time consumed by the intermittent in movement, the wider must be the master blade of the shutter.

In other words, the shorter the period of time the intermittent is in movement with relation to the time it is at rest, the less width of master shutter blade is necessary. Conversely, the slower the movement the wider the master blade must be.

The correct way of describing the speed of the intermittent movement is in degrees. The driving member (cam) of the intermittent movement is circular, and revolves continuously. Every circle is divided into 360 degrees. If the driven member (star) is engaged with the driving member (cam) and in movement during 60 degrees of the revolution of the cam, then the movement is a "60 degree movement," corresponding to a five-to-one movement, because the total cycle of movement is divided into six periods. one of which (60 degrees) represents the time during which the star and intermittent sprocket will be in motion. A true 60 degree movement should allow us to have a 50-50 three-wing shutter because there are three wings and three light openings, or in other words, 6 divisions, and since the time of movement itself is equal to one of the six periods, the shutter blades and the shutter openings may all be equal with each other, always provided there be no lost motion in the mechanism.

NOTE: This is not strictly correct except in theory because of the fact that the lens has considerable diameter the greater part of which must be covered at opening and closing.

In considering the speed of the intermittent we have only to determine whether it is a "six-to-one," a "five-to-one" or whatever it may be, and then divide 360 by the number of cycles in the movement (a five-to-one is, for this purpose, a six-cycle movement, a four-to-one a five-cycle movement and so forth) in order to reduce the matter to degrees. For instance, with a four-to-one we have $4+1=5$, and $360 \div 5=72$, therefore the four-to-one is a 72-degree movement. With such a movement the intermittent would be in action 72 degrees of the entire cycle, and the master blade of the revolving shutter would have to be 72 degrees wide if the light beam had no diameter and if there was no lost motion in the gearing between the intermittent and the shutter. As a matter of fact, however, a sufficient width would have to be added to the master blade to cover about three-quarters of the diameter of the light beam, and to allow for lost motion, so that a four-to-one movement would mean a very bad optically balanced revolving shutter, which would set up tendency to flicker at low speeds, and cut off a very great percentage of the light. The width of such a blade is easily calculated, as follows: Measure distance center of shutter shaft to center of diameter of projection lens. Multiply this measurement by two. Multiply that result by 3.1416 and divide that result by five, or the total number of cycles in the movement, meaning that if it be a six-to-one movement, then the divisor would be seven. The result will be the necessary width of master blade in inches at center of light beam, measured on the arc of a circle, if the light beam had no diameter.

It must be remembered that whereas we may not hope to have a revolving shutter cut much less than fifty per cent. of the light, still we may have it cut decidedly more than fifty per cent., and the nearer we can approach to the best possible condition the greater the percentage of the light we will be enabled to get through to the screen, and the better will be the condition as regards flicker.

LIGHT BEAM DIAMETER.—From the foregoing it will be observed that the diameter of the beam of light at the point at which it is cut by the revolving shutter is a matter of much importance, since the wider the light beam the greater length of time will be required for the shutter blade to cut through it, therefore the wider must be the master blade of the shutter.

To grasp the meaning of this, remember that the master blade of the shutter travels at a uniform rate of speed, consuming, let us assume, 5/80 of a second in making one complete revolution. It will therefore require a longer space of time for the edge of the blade to cut through a beam two and one-half inches in diameter than it will to cut through a beam one inch in diameter. Also it is evident that since the speed of the blade, as measured in inches per second, increases directly as the distance from the center of the shutter shaft is increased, the greater the distance from the center of the shutter shaft to the center of the light beam, the less time will be consumed by the edge of the master blade in cutting across a beam of given diameter. Therefore the greater the distance from the center of the shutter shaft to the center of the light beam the less important increased diameter of the light beam becomes.

Figure 228 shows the effect of added distance center of shutter shaft to center of light beam. At 2 45/64 of an inch a 1.5 inch circle occupies 32 degrees and 12 minutes. At 3 17/64 inches the same diameter circle covers only 26 degrees and 28 minutes, while if the distance be 3¾ inches the same circle occupies only 22 degree and 54 minutes. A 1.5 inch circle represents what is popularly known as a "quarter size lens." From this we see that added distance from center of shutter shaft to center of light beam makes for better conditions as to width of master blade of revolving shutter.

No matter what the distance may be, however, the less the diameter of the light beam the quicker the blade will cut across it, therefore since the master blade must cover three-quarters of the beam when the film begins to move, and continue to cover three-quarters of it until the film has stopped, it is apparent that the less the diameter of the beam the narrower may be the master blade, therefore it follows that:

The shutter blade should be set at the narrowest point of the light beam in front of the projection lens.

We therefore see that insofar as concerns necessary width of the master blade there are three governing elements, viz.: speed of intermittent movement, distance from center of shutter shaft to center of light beam and diameter of light beam.

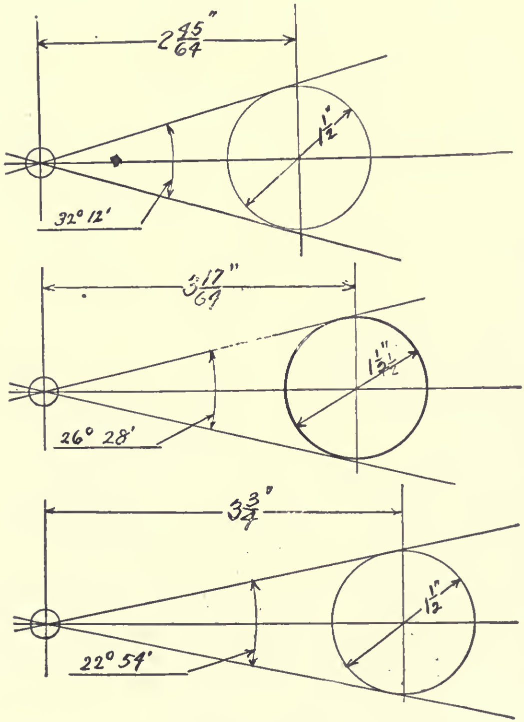


Figure 228.

AERIAL IMAGE.—The front surface of the converging condenser lens is focused at a point in front of the projection lens, except in the case of very short focal length projection lenses, in which case the image may be inside the lens barrel. The distance the aerial image will be from the projection lens will depend upon the distance of the condenser from the projection lens and the focal length of the projection lens itself. As a general proposition the revolving shutter should be set at the point of the aerial image. This does not, however, always hold good.

TO FIND THE IMAGE.—The location of the proper shutter position may be found in three different ways, as follows: (a) place a metal plate, in the center of which is a hole about one-quarter of an inch in diameter, over the face of the converging lens and project the white light to the screen. Blow smoke in front of the projection lens, and you will see that the resultant beam gradually narrows down and then spreads out again. The correct shutter position is at the narrowest point. (b) Project the white light to the screen and slowly pass some opaque object down through the light beam at varying distances in front of the lens. You will find a point at which either two shadows appear simultaneously on the screen, one at the bottom and one at the top, or else the whole screen "dissolves" into darkness. In the first case the point at which the shadows meet exactly in the center of the screen is the correct shutter position. In the second case the point at which the dissolving effect is most perfect is the right place. (c) Project the white light to the screen and hold a piece of black paper or some very dark colored, non-gloss object in the light beam in front of the projection lens, moving it slowly away from the lens until a sharp image of the converging lens of the condenser appears thereon. This test may be made more accurate by first printing some word on the face of the converging lens, using ordinary ink, and then focusing the printing.

The last method locates the aerial image and you can see at a glance whether it is advisable to set the shutter at that point or not, because you can measure the diameter of the beam at that point. If the beam at that point is either more narrow, or even as narrow as it is at any other point, then that is the place for the shutter, but if at a point nearer the lens the beam is more narrow (as is the case under some conditions) then the shutter should be set at the most narrow point of the beam.

DISSOLVING EFFECT.—The reason we say the revolving shutter should be set at the aerial image unless the beam be actually of greater diameter at the image than it is nearer the lens, is because of the fact that at the aerial image there is a dissolving effect, which may or may not enable the use of a less width of master blade. In any event, we believe it will produce a better effect.

THE WHY AND WHEREFORE.—Remember this. There is no manner of use in setting your shutter at the most narrow point of the light beam unless you take advantage of the opportunity that act affords, which is to reduce the width of the master blade. MERELY TO CHANGE THE LOCATION OF YOUR SHUTTER FROM A WIDER TO A MORE NARROW POINT IN THE BEAM HAS NO EFFECT WHATEVER except that if you have travel ghost it may be made less or eliminated entirely by moving the shutter to where the beam is more narrow—has less diameter.

The gain is just this: If your shutter is cutting the beam, without travel ghost at a point at which it, the beam, is wider than it is at some other point, then if you change the location so that the master blade cuts the beam at a more narrow point you can trim something off the master blade, thus enabling you to work more efficiently—to cut a less percentage of the light, and to obtain a better optically balanced shutter.

HOW TO TRIM SHUTTER BLADE.—There is a right way and a wrong way to do everything. After you have located your shutter at the narrowest point of the beam, the next thing is to determine how much can be trimmed off the master blade, and while you can probably estimate the amount pretty closely by slowly revolving the shutter and seeing where its edge is with relation to the light beam when the intermittent starts and when it stops, still if you get too much trimmed off your shutter blade is ruined. It is therefore advisable to proceed as follows: Get from a print shop a piece of stiff card-board about twelve inches square, such as heavy business cards are printed on. Remove the revolving shutter from its hub. Lay the metal blade on the paper and trace its blade edges thereon, afterwards cutting the paper so that you have a paper shutter with blades and openings exactly the same width as those of the metal blade. Never mind the outside rim. You may not think it, but if you are careful not to bend the paper so that you wrinkle it, such a paper blade will run for weeks, or even months.

Now place your paper blade in the hub, put it on its spindle and set the shutter correctly, though the necessity for setting may be avoided by making a mark on the hub of the shutter and on the metal blade before removal, and then making a mark on the same place on the paper blade, setting the two together when you assemble the paper blade and the hub.

Having installed your paper shutter, gradually trim off just a little bit at a time from one edge of the master blade until a tiny bit of travel ghost appears. Next trim off a little at a time from the other edge of the blade until a little bit of travel ghost appears. Having done this, remove the paper blade, lay it on the metal blade and cut the metal blade so that it is just a little wider on each side than the master blade of the paper shutter. This added width will kill the travel ghost, unless you have trimmed down too much on your paper master blade. You can now re-install the metal blade with the assurance that it is cutting the least possible percentage of the light.

Having done this, it is well to consider carefully whether a corresponding amount can be taken off the flicker blade. If the flicker blades are already more narrow than the master blade, then we would not advise this, and this is the condition you will probably find with the three-wing shutter. With the two-wing shutter the blades will probably be the same width, in which event you can trim off the flicker blade edges as much as you did off the master blade.

SHUTTER AND LOCAL CONDITIONS.—It is a very serious mistake to assume that the revolving shutter sent by the projector manufacturer is necessarily correct. It usually is not correct, though that is no fault of the manufacturer, who cannot possibly know under what local conditions any given projector will be obliged to work.

The manufacturer usually sells his projector through supply houses. Any given projector may have to work under a local condition requiring either a very short focal length or a very long focal length projection lens, and a projection lens of maximum or minimum diameter. The manufacturer, therefore, is compelled to send a revolving shutter which will prevent travel ghost under any except the very worst conditions. The dealer (supply house) usually knows little, and perhaps cares less about the optics of projection, therefore he is unable to determine what particular shutter blade width will be required under any given local condition.

It is up to the projectionist himself to fit the revolving shutter to the local condition, and any projectionist who is unable to do this, and to do it intelligently, is not a compe-

tent projectionist. He cannot get the best results except where, purely by chance, the shutter sent happens to fit the condition under which it must work.

We might add that:

Tendency to flicker increases with screen brilliancy and with the size of the picture. Conversely, it decreases with decrease in screen brilliancy and decrease in size of picture.

THE SHUTTER AND ALTERNATING CURRENT.—Where 60 cycle A. C. is used at the arc the use of the three-wing shutter is inadvisable for the following reasons: 60 cycle A. C. reverses its direction (alternates) 120 times per second, or 7,200 per minute. When a projector running at the rate of 60 feet of film per minute is equipped with a three-wing shutter, the light is cut 2880 times a minute. Half of the alternations per minute is 3,600, and if the cycle of the current happens to be not quite 60 (as often is the case) but 55 to 58 instead, it would require but just a little over-speeding of the projector to bring the wings of the shutter into synchronism with one side of the alternations. Under this condition, if the wings happen to cut the light at the point of its greatest brilliancy (See Fig. 4, Page 16), the brilliancy of the light on the screen would be diminished by probably one-half, or maybe even more. And this is what very often does take place where an attempt is made to use a three-wing shutter in conjunction with a 60 cycle A. C. projection arc. The net result is that screen brilliancy will die down and come up time after time, and in a way which is very mysterious to the uninitiated. This is because of the fact that in order to dim the light the shutter must be precisely in synchronism with the alternations, and while this may occur, it is not at all likely the synchronism would be long maintained because an almost infinitesimal variation of the speed of the projector would throw the shutter out of synchronism with the alternations, with result that the screen brilliancy would come back to normal. Put in simple words the effect of this is that screen brilliancy will alternately diminish and increase; decreasing when the shutter blades happen to be in synchronism with the one side of the alternations, and increasing when they are not.

TWO-WING SHUTTER FOR 60 CYCLE.—For the foregoing reason it is advisable that a two-wing shutter be used with 60 cycle A. C., unless the speed of projection be such as will preclude the possibility of the shutter, blades and alternations getting into synchronism.

TWO-WING AND THREE-WING SHUTTERS.—Except in the case of 60 cycle A. C. we advise the use of the three-wing shutter, provided the condition is such that it can be at least fairly well optically balanced. It is true that as a general proposition the two-wing shutter will cut a somewhat less percentage of the light than the three-wing shutter, but it is also true that with modern brilliant projection it is seldom possible to run a picture at normal speed when using a two-wing shutter, without producing flicker.

It does not necessarily follow that under all conditions the three-winger will produce appreciably less flicker at the given speed than the two-winger. We would suggest to the projectionist that he test the matter by installing a three-wing shutter and getting it into the best condition the local condition will allow. Project white light to the screen and find out how low a speed it can be run at before flicker appears. Then put on a two-wing shutter and make the same test. If the two-wing shutter produces no flicker at the lowest speed you use, then the two-winger is to be preferred, but if it does produce flicker at your lowest speed, then the three-winger is to be preferred, because you can get all the really necessary screen brilliancy with it, and current is cheaper than flicker. Also it is better to have photoplays run at the proper speed, even though it be at the expense of some screen brilliancy.

We have explained all this at considerable length in order to give projectionists a clear understanding of the various points involved.

SETTING THE SHUTTER.—The setting of the revolving shutter is to the novice a very mysterious operation. It is, however, almost childishly simple once the underlying principle is understood. The master blade of the revolving shutter is, or should be, stamped with some distinguishing mark. If it is not, then you are safe in selecting the widest blade as the master blade. Loosen the shutter so that it may be revolved by pulling a little while you hold the projector fly-wheel stationary. Turn the fly-wheel until the intermittent sprocket is just barely ready to move, pull the shutter around in the direction it normally runs until its edge covers about three-quarters of the lens, tighten the holding screws, but not so much that you cannot pull the shutter around on its hub or shaft by exerting a moderate amount of force. Thread a film into the projector, preferably one having a white lettered title with black back ground. Project it, and if there are white streaks up and down from the letters, or from white objects in the picture, move the shutter slightly by pulling it around. If this makes the matter worse, then you have moved it the wrong way. Move the shutter until the white streaks disappear, whereupon you are all right. That is all there is to "setting the shutter."

If there should be travel ghost both up and down it is evidence that the master blade of the shutter is not wide enough. A condition of this kind may be eliminated by riveting a small, light piece of sheet metal to each edge of the shutter blade (each edge to preserve the balance) or by

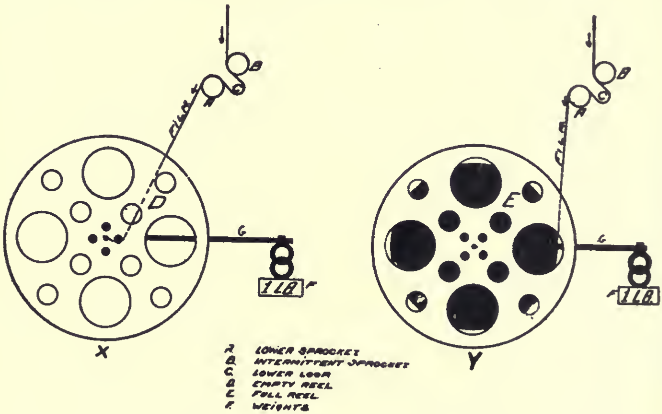


Figure 229.

moving the shutter to a more narrow point of the light ray, if it is not already at the narrowest point.

ONE-AND-A-HALF-TO-ONE SHUTTER.—This type of shutter is in effect a three-wing shutter, though it has but two blades. This is by reason of the fact that instead of revolving once to each complete cycle of the intermittent, as do other shutters, it makes one-and-a-half revolutions to each cycle of the intermittent. This means that if we number its two blades 1 and 2, and No. 1 is master blade at the movement of the intermittent, No. 2 acts as flicker blade and No. 1 does also, No. 2 coming in front of the lens as master blade at the next movement of the intermittent. This type of shutter has the advantage of high speed, which causes the edges of the master blade to cut across the light beam faster, hence increased diameter of beam is not of so much importance as with the regular type shutter. Beyond this we do not feel it to be the province of this work to discuss the relative merits of the two types. The Baird projector uses the one-and-a-half-to-one shutter.

GENERAL INSTRUCTION NO. 23—TAKE-UP.—Most modern projectors are equipped with a take-up device which more or less automatically equalizes the pull on the film, and that a very efficient equalizer is essential is made evident in Fig. 229 in which A represents the lower sprocket of the projector. Suppose with the film attached to the one and one-half inch diameter hub of an ordinary reel as per Fig. 229, and that a lever, G, be attached to the shaft carry-

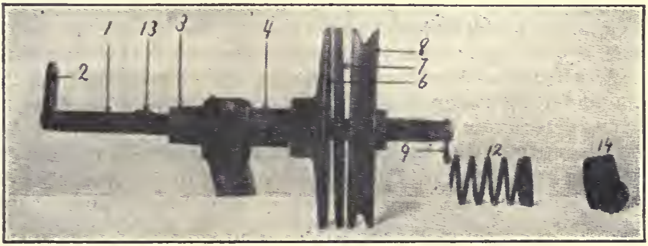


Figure 230.

ing the reel, if we place a one-pound weight at the end of the lever, it is very evident that the amount of pull on the film at X will be very many times more than the pull on the film at Y, and there lies the kernel of the take-up nut. The lower, or take-up reel is driven by the projector mechanism which runs at a continuous and presumably steady rate of speed, feeding sixty or more feet of film to the take-up reel per minute. You will readily see that under condition X, the reel will have to run very fast as compared to its necessary speed under condition Y in order to wind up the film. We see from this that the take-up reel which is driven by a power having steady speed, must itself run at a speed varying from very fast to very slow, which means there must be slippage somewhere between the driving and the driven members.

One way of accomplishing this is shown in Fig. 230, in which 8 is a pulley driven by a belt connecting with the projector mechanism, 1 is a shaft upon which this pulley rides. Pulley 8 is not attached to the shaft, but revolves freely thereon. Six is a cast iron disc attached to shaft 1 by means of a pin or set screw, so that the two must revolve as one member. Thirteen is the key which locks the take-up reel to shaft 1, and part 2 is the lock which holds the reel on the shaft. Between pulley 8 and disc 6 is a washer, 7, made of fiber. The action is as follows: Spring 12 is placed on the end of shaft 1 and against pulley 8. It is followed by collar 14 in which is a set screw. It will readily be seen that pulley 8, disc 6, and washer 7 will be clamped together by the pressure of spring 12, and that the amount of pull pulley 8 will exert on disc 6 through washer 7 before it will slip on washer 7 will depend upon the amount of pressure spring 12 exerts, which same may be altered by altering the position of collar 14.

This is the old style friction take-up; its trouble is that it must be set tight enough to revolve the reel under condition Y, which means that it will exert a very heavy pull on the film under condition X, Fig. 229. All the old style take-up did was to allow sufficient slippage between drive-wheel 8 and disc 6 to accommodate the slowing up of the reel as the film roll grew larger. This condition has the objections that it (a) tends to cause the losing of the lower loop, (b) it exerts an unnecessary and highly injurious strain on the perforations of the film, (c) it has a tendency to pull weak patches in two and (d) it has a very decided tendency to scratch the first hundred feet of film.

CAUTION.—Projectionists who are using old style take-ups should be very careful to set the tension as lightly as is possible without danger of failure to rewind the entire film.

THE MORE YOU KNOW THE GREATER VALUE YOU ARE TO YOUR EMPLOYER.

The Power's Projector

THE Power's projector may be had in several models, the latest being the six-B, with Type E lamphouse.

Figs. 231 and 232 supply dimensional data which will be of value in planning the projection room.

Type E lamphouse is illustrated in Fig. 233. It is 11.5 inches wide, 18 inches front to back and 22 inches from floor to roof. The doors are well braced and double walled, with a half-inch air space between the two walls through which air circulates. The metal used is heavy Russian iron.

The top is so arranged that it may be connected with a pipe leading to the open air or to the projection room vent pipe. In the right hand door is a pin-hole projector with a ground glass screen, held out two inches by a metal casing, upon which screen an image of the crater is projected. Upon this screen lines either are, or may be scratched to represent the proper 55 degree angle position of the crater. The other door has an ordinary observation hole covered by a colored glass.

In the right hand back corner is a small incandescent lamp so arranged that it lights when lamphouse door is opened.

The condenser mount is illustrated in Fig. 234. The lenses are carried in a metal holder which is calculated to equalize the expansion of the thin edge and thick center of the lens, and thus reduce breakage. The lamp rack-bars are three-quarters of an inch square. The bearing through which they slide is 2½ inches long. The surfaces which grip the carbons are 1¼ inches long, of cast iron, dull nickeled. The carbon clamp screws are 5/16 inch in diameter; the leverage for clamping the carbons is ample.

USE GRAPHITE.—The carbon clamp screws and other working parts of the lamp must be kept lubricated with powdered graphite. A dry, unlubricated carbon clamp screw is an abomination and a nuisance. The construction of the lamp, as a whole, is rigid and good. On the front of the bearing carrying the rack bars is a heat shield of asbestos. The lamp has all the necessary, usual adjustments. The dowser is inside. It has two handles so that it may be operated from either side of the projector. These handles

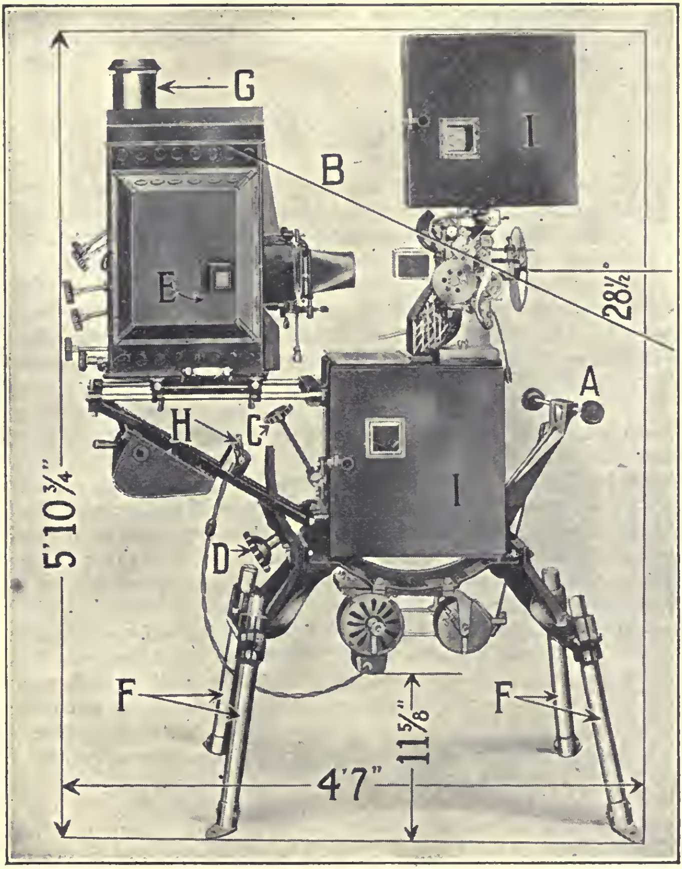


Figure 231.

AA—Speed control knobs. B—Maximum possible angle projector may be set at, which is 28½ degrees. C—Screw for adjusting projector angle. D—Lock to hold projector at desired angle. E—Ground glass screen upon which image of crater is projected. FF—Telescoping legs, by means of which the projector, as a whole, may be lowered 11½ inches. G—Vent cap; may be lifted off for connection to a vent pipe. H—Projector motor switch; handle on both sides. II—Magazines take 1,000- or 2,000-foot reels.

NOTE.—At extreme possible angle (28½ degrees) total height of projector is increased to 6′ 9.5″, floor to top of vent cap, and total front to back length is increased to 4′ 10″. Outlet for arc lamp circuit should be four feet from front wall, plus whatever distance bottom of front legs will be from the wall.

are at A, Fig. 234, which figure shows the condenser holder tipped down to get at the lenses. When tipped back up it is locked into place by handle B. C, Fig. 234, is the screw by means of which the distance between the collector and converging lenses is altered.

INSTRUCTIONS FOR CARE AND ADJUSTMENT OF POWER'S PROJECTOR MECHANISMS.—While at first glance these instructions may seem complicated, they are in fact very simple and quite easily applied. In what follows it is intended to provide all necessary instruction for anything the projectionist may be called upon to do in connection with Power's projector mechanisms and speed controls and we have tried to make the instructions so plain that even the uninitiated may follow them without much trouble.

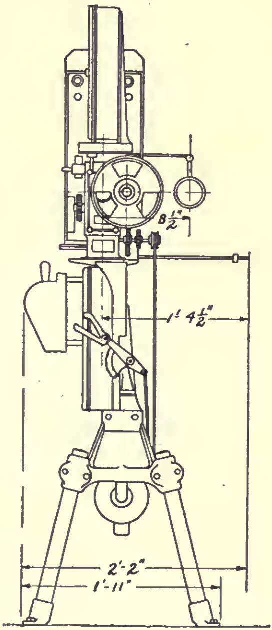


Figure 232.

The Power's mechanism are of the "open" type, which means that there is no inclosing casing. The projector may, by a very simple arrangement, be set at varying heights from the floor. It may be tilted to any angle within the limits of practical projection, either up or down.

In referring to these instructions the numbers indicate the illustration in which they occur and the particular part in the illustration, thus: 659, P. 2, indicates the part numbered 659 in plate 2, which in this case is the intermittent sprocket idler roller bracket.

INSTRUCTION NO. 1—REMOVING MAIN DRIVING GEAR AND SHAFT.—To remove main driving gear 630, P-4, and its shaft 631, P-4 and P-7: First remove crank 632, P-5, and the taper pin 789, P-2, which engages the slot in the hub of the crank. The taper pin 789, P-2, should be driven out from its small end. Having removed the pin, the shaft and gear may be withdrawn, and if desired the gear may be removed from the shaft by driving out the taper pin in its hub.

On mechanism equipped with the adjustable shutter bracket, it will be necessary, before proceeding with instruction No. 1, to remove the adjusting spindle P. 9. This is accomplished by removing the nut D which is secured by a set screw, then turning the knurled knob A to the left, when facing the gate, until the spindle B is free from the split nut C. The spindle B can then be withdrawn from the shutter bracket and gear 630 removed as directed above.

INSTRUCTION NO. 2—TO REMOVE SHAFT 618, P-4, CARRYING GEARS 620 AND 619, P-4.—First follow in-

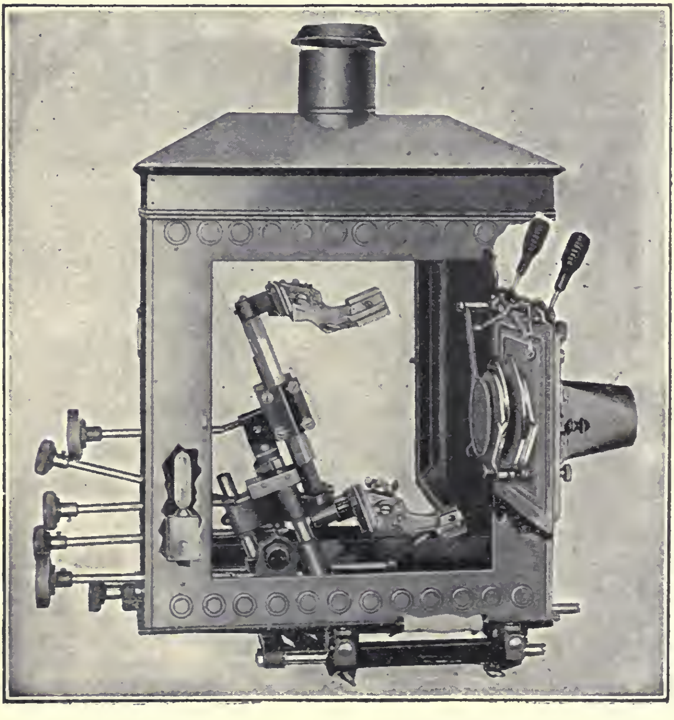


Figure 233.

structions No. 1, then loosen screw 782, P-2, whereupon the shaft and gear may be withdrawn from the gear side.

INSTRUCTION NO. 3—REMOVING AUTOMATIC FIRE SHUTTER GOVERNOR COVER.—To remove the automatic fire shutter governor cover 623, P-2, loosen screw 740,

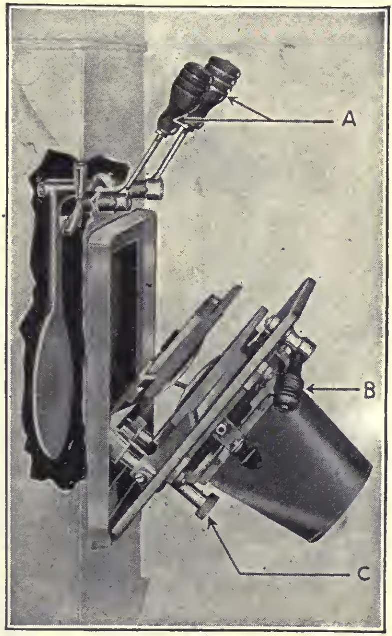


Figure 234.

A—Dowser Handles. B—Lock Handle. C—Screw to change spacing of lenses.

P-2, backing it off considerably, as it is countersunk into the shaft. This releases cover 623 (shown on the left in Plate 9). If the cover does not pull off readily, tap gently on the end of the shaft, at the same time pulling on the cover.

CAUTION.—Do not try to pry the cover off by inserting a screw-driver point between part 623 and 624, P-2. If you do you will probably succeed in ruining your governor.

INSTRUCTION NO. 4—TO REMOVE FRICTION CASING OF AUTOMATIC FIRE SHUTTER 624, P-2.—Follow instructions No. 3, after which remove 798, P-7, whereupon part 624 may be pulled away.

INSTRUCTION NO. 5—TO REMOVE AUTOMATIC SHUTTER LINK 628 AND LEVER 627, P-7.—Follow instructions No. 3 and No. 4, after which the parts may be released by taking out a screw on the reverse side of part 624.

INSTRUCTION NO. 6—ADJUSTING FIRE SHUTTER GOVERNOR.—Should automatic fire shutter 697, P-1, fail to

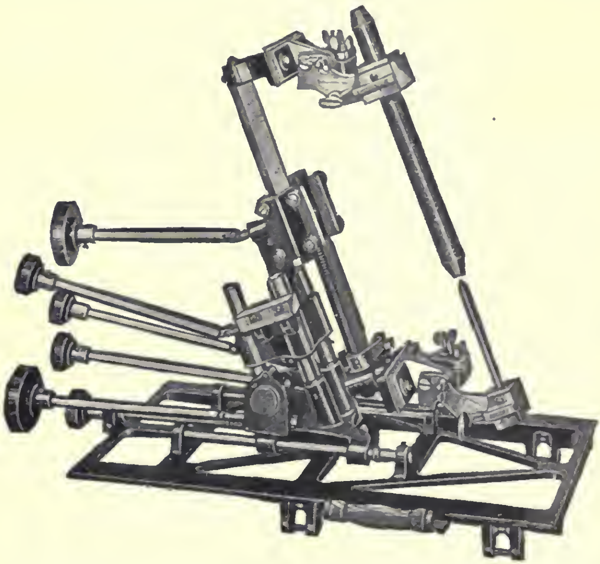


Figure 234-A.

The Power's Late Model Lamp.

drop, examine lever 627 and links 628, P-7, and see that they work freely and are not bent. Usually the binding of these parts is responsible for the sticking of the fire shutter. If this is not found to be the seat of the trouble, remove cover 623, P-2 (see instruction No. 3), and carefully examine springs 717, P-9, also examine the inside edge of friction casing 624 and see if track "Y," Plate 9, is smooth, as it should be, and not scratched or rough. If it is rough or scratched, carefully polish track "Y" by using No. 00 emery cloth.

CAUTION.—Do not use coarse emery cloth or you will only succeed in making matters worse.

Should the automatic fire shutter fail to rise properly, first try injecting a drop of heavy oil in the oil hole on top of 624, P-2. The clutch shoes 625, P-9, act by centrifugal force, which throws out weights 626, P-9, against the action of springs 717, P-9, thus forcing friction shoes 625 against track "Y" on part 624, P-9. The friction thus engendered revolves casing 624 in clock-wise direction, which forces lever 627, P-7, ahead and raises shutter flap 697, P-1. Do not use thin oil on the automatic shutter, as it tends to reduce the friction too much. Use heavy oil sparingly. Should the fire shutter rise too quickly, or should the governor develop undue friction, thus making the mechanism pull hard, it will

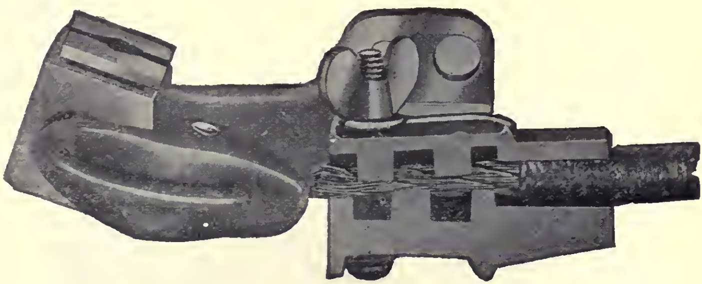


Figure 234-B.

Power's Late Model Arc Lamp with Terminal.

probably be found that springs 717, P-9, have become weakened. This may be remedied by installing new springs or by stretching the old ones. Another possible cause of failure of the fire shutter to act, or to act too slowly, is the binding of the screws at the top or lower end of link 628, P-7. This link must swing perfectly free. In the centre and top of fire shutter flap 697, P-1, is a pin. This pin not only serves to hold the flap to its spindle and prevents its slipping circumferentially, but it also prevents the shutter from rising too high. Therefore, it should not be allowed to become loose and fall out.

INSTRUCTION NO. 7—REMOVING TOP ROLLER BRACKET.—Top roller bracket 612, P-2 and 7, may be removed by taking out stud 710, P-7.

INSTRUCTION NO. 8.—REMOVING TOP SPROCKET IDLER ROLLER 609, P-2.—This may be removed by loosening screw 733, P-2, pulling the shaft out and taking out the collar next the roller. This roller should be replaced if there is any indication of flat spot on its surface. Before adjusting these rollers, see general instruction No. 12.

INSTRUCTION NO. 9—REMOVING TOP AND LOWER SPROCKETS.—To remove the upper sprocket 617, P-7, first remove the upper apron 629, P-2, by removing the two screws, one at each corner. Then loosen the screw in the centre of the hub of sprocket 617, P-2, pulling the sprocket off the shaft. The lower sprocket 646, P-2, can be removed by loosening the small screw in the centre of hub of sprocket and pulling sprocket off the shaft. See general instruction No. 3 concerning keeping sprockets clean.

If film seems to bear equally on both edges of both sprockets and the aperture plate tracks are not straight

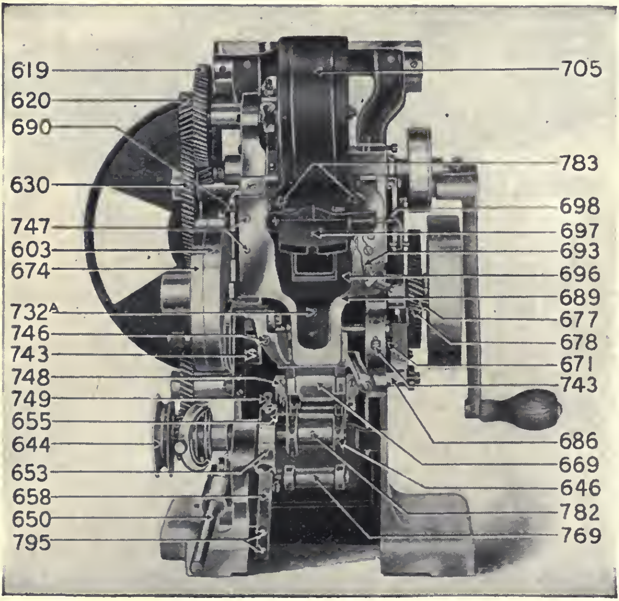


Plate 1, Figure 235.

with film it would indicate aperture plate out of true. Gently drive its top one way or the other, as is required, to square it with the film. The first thing to do, however, before making this test is to be certain your intermittent sprocket shaft is in exact alignment with camshaft.

INSTRUCTION NO. 10—TENSION OF UPPER IDLER ROLLER.—Upper sprocket idler roller 609, P-2, is held to the sprocket by a flat spring, 615. Should this spring at any time become too weak, it may be strengthened by removing the idler roller bracket (see instruction No. 7) and bending the top of the spring outward until the desired tension is obtained.

INSTRUCTION NO. 11—REMOVING THE GATE.—The entire gate, including cooling plate 696, P-1, automatic fire shutter flap 697, P-1, and hinge 690, P-1, may be removed

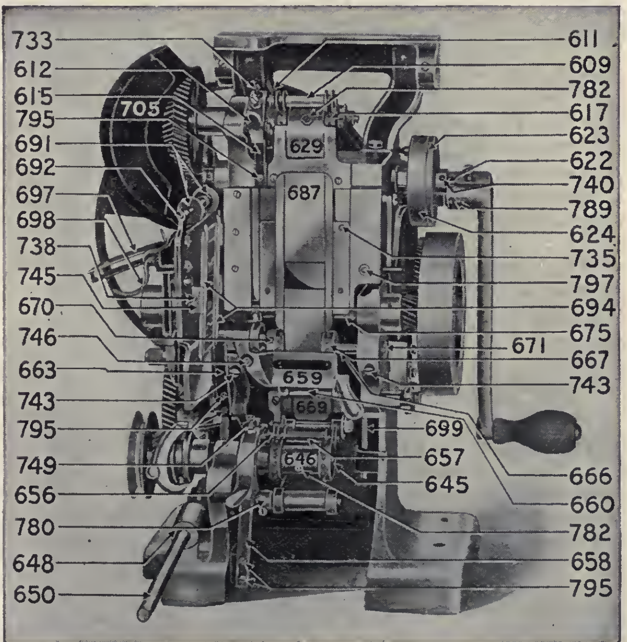


Plate 2, Figure 236.

by taking out screws (three of them) 747, P-1. In replacing the gate, before tightening up screws 747, P-1, be sure that the top gate guide rollers 691, P-3, centre properly with the aperture plate. After replacing the gate project the white light to the screen. If there is a shadow at the top, bottom or side, open the gate. If the opening of the gate removes the shadow, then it means that your gate is not properly centred, and you must loosen hinge screws 747 and move gate until the shadow disappears. Be careful, however, that the gate guide rollers 691, P-3, are kept spaced central with aperture and sprocket, as per Fig. 224.

INSTRUCTION NO. 12—REMOVING AND ADJUSTING TENSION SHOE.—Tension shoe 694, P-2, may be removed by first pulling out the pin in the gate-hinge 690, P-1, after which remove screws 738 (one on either side), P-2. This releases the tension shoe.

INSTRUCTION NO. 13—REMOVING TENSION SPRINGS.—Between the face of the gate and cooling plate

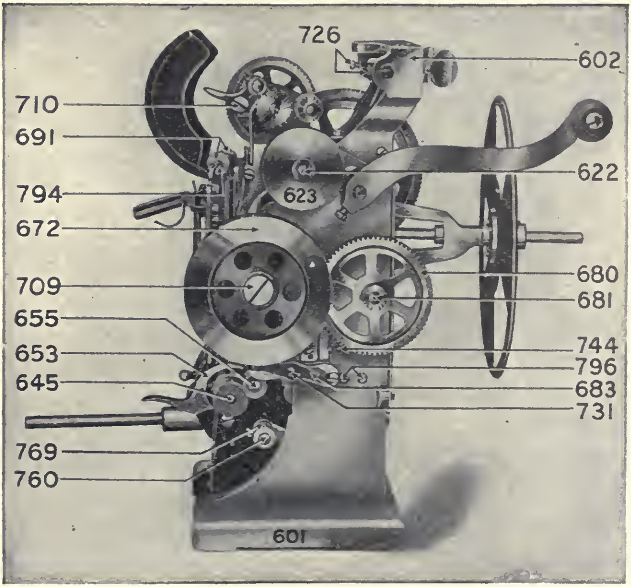


Plate 3, Figure 237.

695, P-1, are the tension springs and the tension spring equalizer. Should it at any time be necessary to remove either of these, take out flat-head screws just above and below the cross-bar joining tension shoe tracks 694, P-2. This will release cooling plate 696, P-1, and expose the parts. In replacing, be sure that the little flat spring which acts on gate latch 693, P-1, rests against the latch and not on top of it.

INSTRUCTION NO. 14—REMOVING COOLING PLATE. —(See instruction No. 13.)

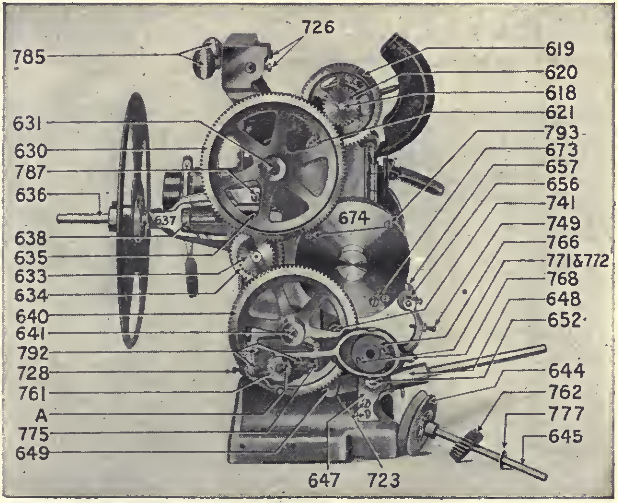


Plate 4, Figure 238.

INSTRUCTION NO. 15—ADJUSTING TENSION.—The pressure of the tension shoes is governed by screw 732A, P-1. Setting this screw inward increases the tension and conversely loosening the screw decreases it. THE TENSION SPRINGS SHOULD BE KEPT SET EXACTLY RIGHT. SEE GENERAL INSTRUCTION NO. 9.

INSTRUCTION NO. 16—APERTURE PLATE.—Aperture plate 687, P-2, may be taken off by removing screws 735 (four of them) and pulling the plate away. In replacing the aperture plate, proceed as follows: Put the plate in place and insert the four screws holding it, tightening them down just enough so that by tapping lightly on the edge of the plate it may be moved either way. Now project the white light to the screen and move the aperture until the upper and lower lines of the light are level on the screen whereupon tighten up the four screws.

CAUTION.—In removing parts of this kind, remember that the screws are small. Do not lay them down anywhere, depending upon luck to find them. Have a cigar box or small receptacle of some kind in which to place all screws, or in lieu of that, replace them in the holes when you take the part away. Then you will know where they are when you want them. A magnetized screw-driver is a fine thing to handle small screws with. See general instruction No. 19.

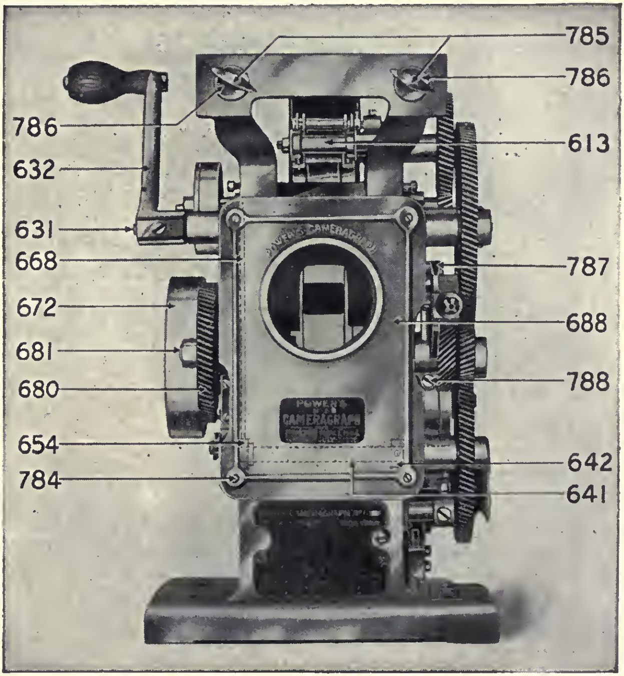


Plate 5, Figure 239.

INSTRUCTION NO. 17—ADJUSTING GATE LATCH SCREW.—The right-hand edge of the face of the gate and its left-hand edge should set an equal distance away from the face of the machine casting, since otherwise the tension shoe will exert greater pressure on one side than will the other. This is regulated by the gate latch screw 797, P-2. This screw should be set at a sufficient distance to bring the entire gate square with the face of the machine casting and the lock nut thereon should then be set up tight to prevent any change in this adjustment.

INSTRUCTION NO. 18—REMOVING INTERMITTENT ROLLER BRACKET.—Roller bracket 659, P-2, may be removed by taking out the screw in its hinge, first, however, having loosened screws 795, P-2, holding the spring 663, P-2. The distance of the idler roller which this bracket carries from the intermittent sprocket may be varied by tightening or loosening screw 746, P-2. See general instruction No. 12.

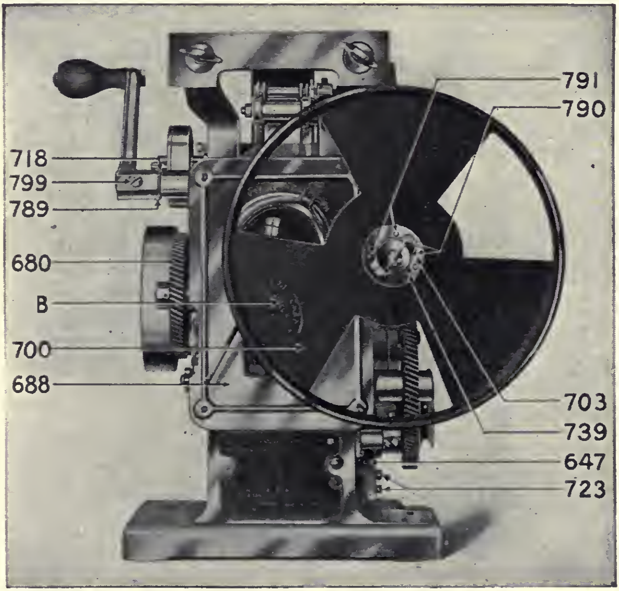


Plate 6, Figure 240.

To vary distance of idlers from sprocket first loosen nut on its outer end, then turn the bracket clear up and the head of the screw will be found underneath. The further this screw is backed out, the further the roller will be from the sprocket, and vice versa. After the proper adjustment is made, be sure to tighten lock nut on screw 746, P-2. The tension of this bracket is governed by flat spring 663, P-2. This may be made greater or less by bending the spring. If it is to be made less, just bend the upper end of the spring down, but be careful and do not bend it too much.

INSTRUCTION NO. 19—REMOVING AND ADJUSTING APRON.—Apron 669, P-1, may be taken off by removing two screws (one on either side) near the roller near its base. The adjustment of this apron is quite important. Should the

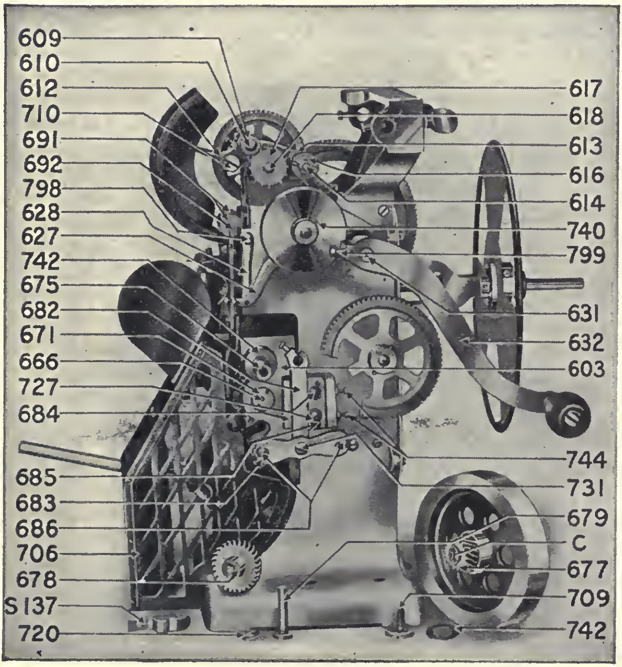


Plate 7, Figure 241.

film make a chattering noise in going through the machine, carefully bend the ears at the lower end of apron 669, P-1, which carry the rollers, ahead slightly, being careful to bend each one the same amount. If this remedies the trouble, well and good. If it helps, but does not remedy it, then try bending it a little more. If it makes it worse, bend the rollers back slightly. You can do no damage by bending these apron ears, provided you keep the rollers square with the sprocket, that is to say, equidistant from the sprocket. To test this, measure from the face of the hub of the roller to opposite teeth on the lower sprocket.

INSTRUCTION NO. 20—REMOVING AND ADJUSTING LOWER SPROCKET IDLER BRACKET.—Lower sprocket idler bracket 653, P-1, may be removed merely by taking out its hinge screw, first, however, loosening screws 795, P-1, holding flat spring 658. The distance of the roller which

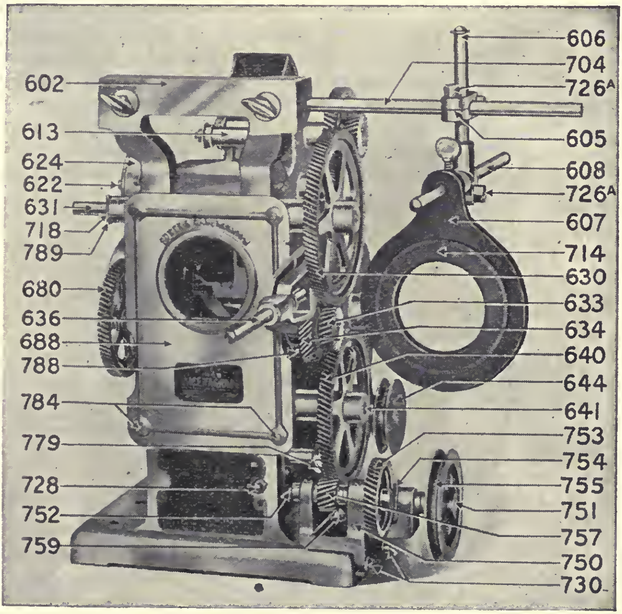


Plate 8, Figure 242.

this bracket carries from the sprocket (see General Instruction No. 12) is determined by the position of the screw 749, P-1. Spring 658, P-1, should supply sufficient tension to this bracket to hold it firmly in place when it is closed down, but this may be overdone. The tension of this bracket should not be sufficient to cause the sprocket teeth to punch through, or even indent the film should it climb the sprocket. This adjustment calls for the exercise of judgment. If it is too tight, damage may and probably will be done to the film.

INSTRUCTION NO. 21—TO REMOVE FLYWHEEL 672, P-3.—Remove screw 709, P-3. If you cannot start this screw with an ordinary screw-driver, grind down the broad end of a file to make a screw-driver for this purpose. Having removed this screw, place the point of the screw-driver right up close against the hub on the opposite side of the wheel, and tap gently until the wheel becomes loose. In replacing the flywheel be sure that groove C in pinion 677, P-7, connects properly with the key on the camshaft. In order to accomplish this, insert the point of a screw-driver between the lugs carrying brackets 659, P-2, and the collar on shaft 675, P-2, and pry gently downward. This will hold the spindle stationary while you twist the wheel until the slot and key come opposite each other. CAUTION: Between pinion 677, P-7, and the hub of the casting it fits up against is a thin steel washer, 742, P-7. This washer fits on the larger diameter of the shaft and you must be careful that it is precisely in place before the wheel is forced on, or you will have trouble. When the wheel is in place, tighten up screw 709, P-3, tight.

INSTRUCTION NO. 22—REMOVING TOGGLE GEAR.—To remove toggle gear 678, P-1 and 1, follow instructions No. 21, then loosen the screw in the upper end of connecting link 682, P-7, whereupon the gear and spindle may be pulled out. The adjustment of this gear is a very important matter. The gear must be exactly centered between flywheel and pinion 677, P-1 and 7, and gear 680, P-3. The toggle gear is carried by connecting link 682, P-7, and its position with relation to the gears on either side of it is determined by the position of the casting 684, P-7. Should a grind develop in this gear, first having made sure that connecting link 682, P-7, is held snugly in its ways by casting 685, P-7, using a soft metal punch, tap lightly first one way and then the other against casting 684, P-7, the idea being to slip the casting slightly against the pressure of the screws which hold it.

The casting cannot be moved much, but sometimes enough movement may be accomplished to remove or reduce a grind.

INSTRUCTION NO. 23—ADJUSTING CONNECTING LINK.—Connecting link 682, P-7, plays an important part, and must be kept tight in its ways. If by shaking horizontal bar 683, P-7, you are able to move connecting link 682, in its ways, then it is too loose and may be tightened as follows: First loosen screws 727, P-7, then release lock nuts on 744, P-7, tighten screws 744 a trifle, next retighten screws 727, P-7, and try the framing lever. If it is still too loose, then you can give them a little bit more, but be careful and do not get them too tight or your framing carriage will bind. In making this adjustment do not set screws 744 in so much that the connecting link fits snugly while screws 727 are loose, because if you do, when you tighten screws 727 the whole thing will be clamped solid. Be sure that screws 727 and the lock nuts on screws 744 are set tight.

INSTRUCTION NO. 24—REMOVING LOWER SPROCKET SHAFT.—To remove lower sprocket shaft, loosen screw 782, P-1, and pull the shaft out to the left.

INSTRUCTION NO. 25—REMOVING LARGE IDLER GEAR.—To remove large idler gear 640, P-4 and 8, remove the mechanism from the stand, then remove motor attachment, if projector is motor operated, by removing screws 730 and 759, P-8, when motor attachment will come away from the mechanism. Turn it bottom side up and, looking, you will see the shaft which holds this gear, and on it, resting against the mechanism casting, a brass collar, the stock number of which is 642, P-5. Move the flywheel until the set screw in this collar comes into view. Loosen the set screw and you may then pull the gear and its shaft out.

INSTRUCTION NO. 26—REMOVING THE LOOP SETTER.—Loop setter fork 768, P-4, may be removed by first following Instructions No. 24 and 25. Then remove stud 775, P-4, which will release the fork and clutch 766, P-4. Loop setter cam 761, P-4, is removed by following Instructions 23, 24 and 25, loosening the two large screws in its face and pulling it off the shaft. Should it be necessary to remove the loop setter arm, carrying roller, 769, P-3, or the spring which provides tension therefor, first follow Instructions 24 and 25, then loosen screws 792 (three of them), P-4, when the loop setter arm may be pulled out though the hole in the mechanism casting. The replacement of these parts is merely a reversal of the process of their removal, but in replacing them be sure that all screws, particularly screws 792 and the screws in cam 761, be set up tight. In replacing the loop setter, be careful that roller 769, P-3, lines with the lower sprocket, or, in other words, that the roller sets perfectly "square with the film," since otherwise when the loop setter acts, the pull would be all on one side of the film and this might, and probably would, cause trouble.

INSTRUCTION NO. 27—ADJUSTING LOOP SETTER SCREW, 728, P-4 is for the purpose of adjusting or regulating the throw of the loop setter arm and roller 769, P-3. This screw should be so adjusted that roller 769, P-3, rests about half-way between the lower sprocket and the top of the front cross bar in the base of the mechanism.

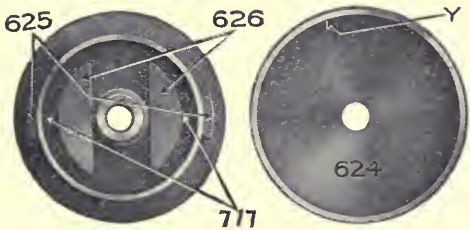


Figure 243.

INSTRUCTION NO. 28—THE SHUTTER BRACKET.—When a new machine is received, shutter bracket 637, P-4, will be folded down against the mechanism, and shutter blade 700, P-6, will be tied to the mechanism. Raise shutter bracket 637, P-4, up until it is in a horizontal position, as shown in plate 4, and screw 787, P-4, has engaged the hook on the upper part of the bracket, first having backed screw 787 out sufficiently so that the hook will pass in behind its head. Now, having raised the bracket clear up, tighten screw 787, P-4 and 5, tight, and then tighten screw 788, P-5, up tight. CAUTION: Do not tighten screw 788 until you have tightened screw 787, because if you do it will probably cause the shutter spindle to bind in the bracket.

INSTRUCTION NO. 28½—TO REMOVE THE SHUTTER BRACKET.—The entire shutter bracket 637, P-4, may be removed from the machine by first following Instructions No. 1, 24 and 25, and loosening screws 787 and 788, P-5. Then drive out the taper pin in the hub of gear 680, P-3, and drive out shaft 681, P-3, carrying with it on the opposite end gears 633 and 634, P-4. To drive out shaft 681, use a brass punch slightly smaller in diameter than the shaft.

NOTICE.—On mechanisms equipped with the adjustable shutter bracket, it will be necessary, before proceeding, to remove the shutter bracket, to first remove spindle B, Fig. 249. To do this proceed as follows: Remove nut D, Fig. 249, which is secured by a set screw, which must first be loosened. Next turn knurled knob A, Fig. 249, to the left (counter clockwise) as you face the screen, or as you face the mechanism gate if the projector is off the stand, until it is disengaged from split nut C. Spindle B may then be withdrawn from the bracket and the bracket may be removed as above directed.

INSTRUCTION NO. 29—REMOVING SHAFT 681, P-3, AND GEARS 633 AND 634, P-3.—See Instruction No. 28.

INSTRUCTION NO. 30—INSTALLING SHUTTER DRIVING GEARS, 633, 634 AND 635, P-4.—DO NOT ATTEMPT IT. If these gears need replacing, it will be necessary to send the mechanism to the factory or to a thoroughly competent repair man. The same applies to shutter shaft 636, P-4. It would hardly be possible for the projectionist to replace gears 633, 634 or 635, or to put in a new revolving shutter shaft, and get the parts adjusted so they would run smoothly.

INSTRUCTION NO. 31—REMOVING SHUTTER FROM HUB.—In P-6, we see a three-blade shutter. This blade may be changed to a two-blade, using the same hub, by loosening screw 739, P-6, pulling the shutter off its shaft and removing the three screws 791, P-6, in the back of its hub. This releases the shutter blade, which may then be changed to another one of different design if desired.

INSTRUCTION NO. 32—SETTING THE SHUTTER.—On projectors not equipped with adjustable shutter bracket as per Fig. 249, shutter 700, P-6, may be set by loosening screw 790, P-6, in hub, which will allow the outer hub to revolve on the inner, and enable the projectionist to set the shutter in any desired position. When a new mechanism is received the revolving shutter shaft will be folded down. Raise it up, loosening screw 787, P-5, until it will enter slot in shutter bracket. Raise shaft as far as it will go and set up screw 787, tight. Next tighten screw 788, P-5, which also holds bracket. Be sure you tighten both these screws after raising shaft into place. Next place shutter on shaft with hub out as shown in P-3, with screw 739, P-6, in V groove in shaft.

Should travel ghost (streaks up and down from letters of titles, or flashes of white up and down from white object in pictures) develop at any time, it may be eliminated by resetting the shutter. Loosen one of the screws 790 and slack off on the other one until shutter can be slipped by applying some pressure. If streaks are up hold flywheel stationary and revolve the top of the shutter away from you slightly, and, with a title having white letters on an opaque background, try it. If the streaks are down, pull top of shutter towards you. Keep slipping shutter slightly and trying until streaks disappear. Then tighten up screws 790. When travel ghost develops, first be sure screw 739, P-6, is set up tight. To set a new shutter, proceed as follows: Place shutter on shaft as shown in P-6, with hub towards end of shaft. Set screw 739, P-6, in groove and tighten it. Loosen screws 790, P-6, so that shutter revolves freely on inner hub. Open gate and turn flywheel forward until intermittent sprocket is just at point of moving. Set shutter as shown in P-6 and tighten one of 790 slightly. Then proceed as directed for travel ghost. For very short focal length lenses the Nicholas Power Company will supply a special shutter on application. Their two-blade shutter should always be used on 60-cycle A. C. The blade with stamp B, P-6, on it is the master blade, and the only one to be considered at all in setting the shutter.

Travel ghost may be caused by (a) screw 739, P-6, being loose. (b) Collars 638, P-4, not set up snugly against bearing, thus allowing end play in shutter shaft. (c) Gear 680, P-3, loose on its shaft. (d) Gear 633, P-4, loose on its shaft. (e) Badly worn gears. Any one of these things, or all combined, may cause travel ghost.. Screws clamping shutter blade in flanges of hub being loose might also be responsible for it.

TRAVEL GHOST may also be caused by master blade being too narrow, in which case it may be removed by moving the shutter to a position where it will cut the light beam at a point where it has less diameter, if there is such a point, or by making the blade itself wider.

NOTICE.—On mechanism equipped with an adjustable shutter bracket, knob A, Fig. 249, should be turned until split nut C is located central between bearings E and F. Having done this you may make a roughly correct adjustment of the shutter as before directed, completing the fine adjustment by turning knob A, Fig. 249, in the required direction after the projector is running.

INSTRUCTION NO. 33—REMOVING OIL CASING COVER.—To remove oil casing cover 674, P-4, follow Instructions No. 24 and 25. Next remove screws 793 (three of them), P-4, and tap lightly on the hub of the cover to break the shellac joint.

In placing this cover back, scrape the edges lightly, but be sure and get them perfectly clean. Then smear edge of the cover (not casing edge, but the cover edge only) with thick shellac and clamp the cover in place. It is better if the shellac dries a little before you put on the cover, but don't let it dry too much. CAUTION: DO NOT PUT ON TOO MUCH SHELLAC. If you do it will squeeze out into the interior of the oil casing and get between the pins and the cam, and may do serious injury to the intermittent movement. Instances have been known where an excess of shellac has broken the geneva pins.

INSTRUCTION NO. 34—REMOVING CAMSHAFT AND CAM.—First follow Instructions Nos. 21, 24, 25 and 33. Then loosen the two screws 743, P-2, in bushings 670 and 671, P-2. Then loosen the two set screws in the collar on shaft 675, P-2, just above arrow head, 670, P-2, move the collar over to the right, and, with a small fine file smooth off the burrs caused by the set screws. The shaft and cam may now be pulled up to the left. CAUTION: In replacing the shaft, do not forget to put collar on and tighten the two screws 743, P-2.

INSTRUCTION NO. 35—REMOVING INTERMITTENT SPROCKET, ITS SHAFT AND PIN CROSS AS A UNIT.—To remove the intermittent sprocket, its shaft and the pin cross as a unit, first follow Instructions Nos. 19, 21, 24, 25, 33 and 34. Next loosen screws 743, P-2, and the entire unit, including the large bushing in which the shaft runs, may be pulled out through the oil well.

INSTRUCTION NO. 36—ALIGNING SPROCKETS.—It is of the utmost importance that upper sprocket 617, P-2, intermittent sprocket 667, P-2, and lower sprocket 646, P-2, and aperture plate be all kept exactly in line. The alignment of intermittent sprocket, upper sprocket and aperture plate may be tested by placing a short strip of film (don't use worn film for this purpose) in the mechanism with the gate open. Place it on the intermittent sprocket and close idler bracket. Engage sprocket holes on film with teeth of upper sprocket and turn flywheel backward until film is stretched tightly, being careful that teeth are in centre, sidewise of sprocket holes. If sprockets and aperture are not in perfect alignment the fact is readily detected by the film edge not being in line with tracks on aperture plate, or aperture not being central in film.

If film seems to bear equally on both edges of both sprockets and the aperture tracks are not straight with film, it would indicate aperture plate out of true. Gently drive its top one way or the other, as is required, to square it with the film. The first thing to do, however, before making the test is to be certain your intermittent sprocket shaft 666, P-2, is in exact alignment with camshaft 675, P-2.

INSTRUCTION NO. 37—REMOVING THE FRAMING CARRIAGE.—To remove the entire framing carriage of the mechanism, first remove the aperture plate (see Instruction No. 16) and the gate (see Instruction No. 11). Next remove the screw 741, P-4, turn the machine around and, looking in through the lens hole, you will see perpendicular rods 669, P-2, the top ends of which are held in cast lugs. Loosen the set screws in these lugs and in similar lugs at their lower ends, and pull these perpendicular rods out from below. Next remove horizontal bar 63, P-3, by taking out screw 731, P-3. The carriage may then be taken from the machine.

INSTRUCTION NO. 38—LUBRICATING GEARS.—See "Gear Lubrication," under General Instruction No. 1, Plate 9, Fig. 243.

INSTRUCTION NO. 39—TO THREAD THE MECHANISM.—See General Instruction No. 20, with the notation that if there be a loop setter the film must pass under its roller, A, P. 10, and should just clear it when the lower loop is at its shortest.

INSTRUCTION NO. 40—THE LOOP SETTER.—The Powers loop setter, illustrated in Plate 10, is a simple device which operates well. It automatically re-sets or re-forms the lower loop whenever it is "lost" by reason of any one of the several causes which may be responsible for this very annoying thing. Plate 10 shows the film forming the lower loop around roller A. When the loop is lost (drawn taut), the roller is necessarily elevated, thus causing a slight rotary motion in cylinder b. A diagonal slot in this cylinder, in contact with a pin fastened to arm C, causes the arm to move outward; but as arm C operates as a lever, with its fulcrum at point D, the other end of the arm at E moves inward, thus disengaging pin F from the driving pulley G. This breaks the connection whereby motion is transmitted to take-up sprocket H, and the sprocket stops revolving. The loop reforms instantly, and roller A is forced back into its original position by coil spring I. Pin F immediately re-engages with driving pulley G, and the take-up sprocket H starts to revolve again as a natural consequence. The whole train of operation is automatic—its results instantaneous.

INSTRUCTION NO. 41—Always wipe edges of aperature before threading.

INSTRUCTION NO. 42—ADJUSTING 6A TAKE-UP TENSION.—The take-up tension is adjusted by setting the collar on pulley end of spindle in or out, thus applying more or less pressure to the spring which holds the two halves of the grooved, split pulley together. Tension is not regulated by the belt, but by the two halves of the pulley rubbing together under more or less friction, according to how much is supplied by the spring. Take off the belt and pull the two halves of the pulley apart a little and you will see how it works. There should be no more tension than barely enough to revolve the reel when it is full. Anything more is very hard on the film and tends to cause loss of the lower film loop. See General Instruction No. 22.

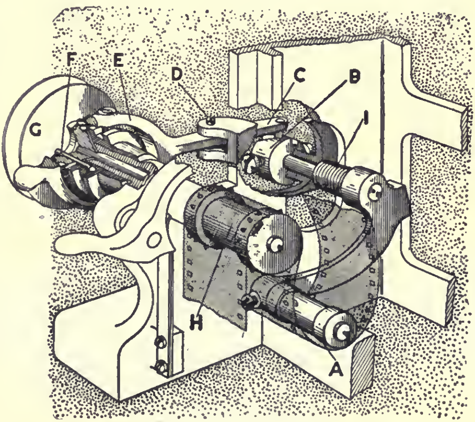


Plate 10, Figure 244.

INSTRUCTION NO. 43—ADJUSTING 6B TAKE-UP TENSION.—The 6B take-up consists primarily of two friction discs, which are held in contact by means of a coil spring. One of these discs is faced with fibre, which assures an excellent frictional contact. The driving disc a, Plate 11, is left free to revolve around take-up spindle b, as an axis. The driven disc c, is fastened to spindle b. By frictional contact, motion is transmitted from disc a, to disc c, and thus spindle b is caused to revolve also. The take-up reel fastens to spindle b at d. The reel is held firmly on the spindle by means of catch e. When the catch is in a horizontal position, it is in exact line with spindle b, thus making it very easy to put the reel on, or take it off the spindle. Spindle b runs in ball bearings f, which eliminate all unnecessary friction in operation.

The friction between discs a and c may be adjusted by increasing or decreasing the tension on spring g. This may be accomplished by simply giving a few turns in either direction to collar h, which is threaded on the end of spindle b. When the desired tension has been secured, the collar may be locked in place by means of set screw i.

INSTRUCTION NO. 44—THE LAMP.—The lamp should not be allowed to become dry from lack of lubrication. It is next to impossible to properly handle the light using a dry lamp. Once a week apply sparingly a little lamp lubricant on all movable parts, such as threaded adjusting gears,

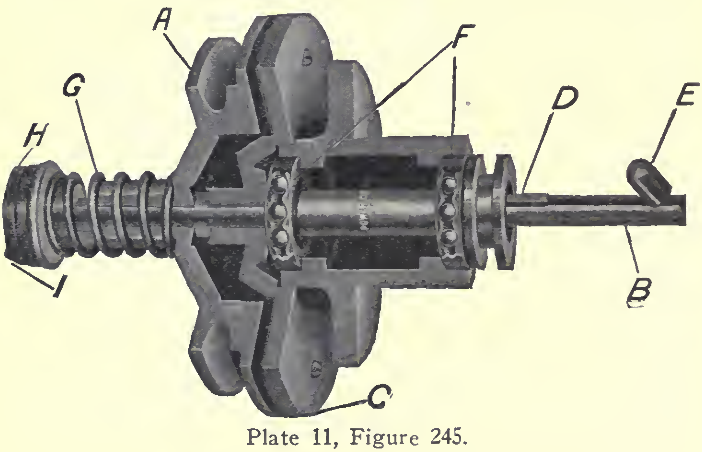


Plate 11, Figure 245.

racks, sleeve rollers, etc. This lamp lubricant is put up in cans by the Nicholas Power Company, Incorporated. Be sure and do not use too much of the lubricant, and do not put any on the mica insulation. You will be surprised how much better you can handle the light. Keep metal clean where carbons make contact with it. Scrape and clean thoroughly at least once a week. Dirty carbon contacts induce heating and loss of power and light. Be sure the wires make a good electrical contact with lamp binding post. When terminal lugs become burned, throw them away and put on new ones. It does not pay to use burned lugs. When wires inside lamp house become burned (the life gone out of them) cut away the burned portion. Burned wires cause high resistance and loss. Unless removed, they will eventually burn off entirely, causing vexatious delay.

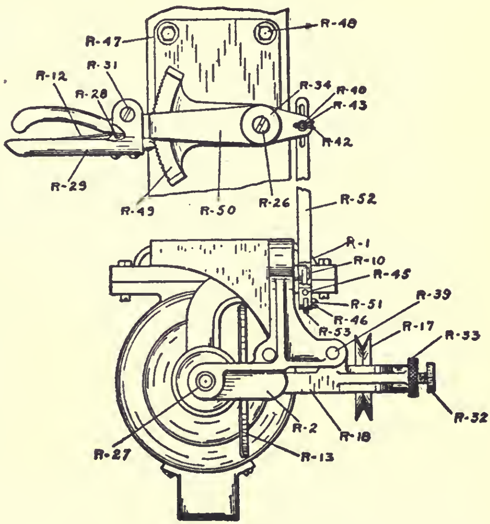


Plate 12, Figure 246.

OLD STYLE POWER'S MOTOR DRIVES.—When using old style Power's motor drives it is important that you have the friction pulley in alignment with disc on motor. When starting show, begin with slow speed and increase until you reach the required projection speed.

When motor drive is not in use, see that friction driving disc R-15, Plate 13, is not bearing on disc R-13, Plate 13. It should be free from contact.

1. Motor should be kept free from dust, and do not allow oil to get into the motor windings.

2. Belt on V pulley should not be too tight.

3. Never put too much pressure on the adjusting screw

R-32, Plate 12, as it flattens the driving disc R-15, Plate 13. If necessary, trim the leather disc just a trifle so that the side first touching the friction disc, when the speed lever is shifted over, is a trifle higher than the other side.

4. Driving disc must be kept free from oil.

5. Grease cups should be kept supplied with motor cup grease and the wicks occasionally trimmed and cleaned.

All Power's projector stands of the later type are drilled to receive Power's speed control. When the projector is received, the speed control parts, as shown in Plates 12, 13 and 14, are assembled, with the exception of the lever R-52,

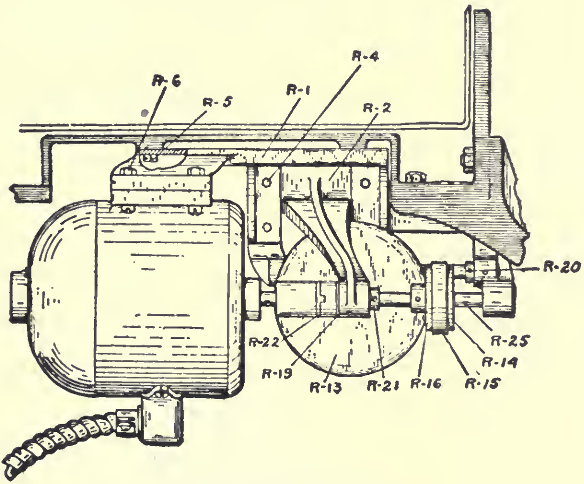


Plate 13, Figure 247.

but the control is not attached to the stand. All that is necessary to attach the control is to place same in the proper position, as shown in Plate P-12 and P-13, with the motor towards the rear end of the projector, and fasten it into place by means of bolts R-5 (four of them) P-13. Be sure that the contacts between the casting and the control are clean and set up bolts R-5 (four of them) tight.

This instruction holds good with both the old style 6A non-adjustable and the new style 6B adjustable stand. It is then necessary to attach the lever control, P-12. If it is the old style 6A non-adjustable stand, this lever and its casting is attached by means of bolts R-47 and R-48, P-12. If it is the new style adjustable stand, then a special bracket is sent. This bracket is attached to the casting by means of two heavy machine screws. Having attached the control lever, all that is necessary to complete the installation is the connecting of lever R-52, P-12, with the end of the control lever at R-42, P-12, and with the bell link R-53, P-12.

NOTE.—All parts except very small screws have the stock number either stamped or cast right into the part—a very excellent arrangement.

All projector stands are drilled to receive the speed con-

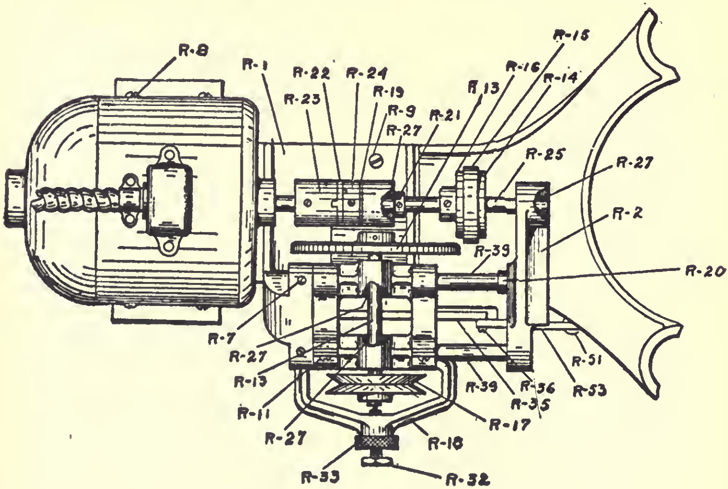


Plate 14, Figure 248.

trol so that you can order same at any time and install as per the foregoing instructions.

INSTRUCTION NO. 1.—The friction material R-15 is leather. Should it at any time develop flat spots or become out of round or eccentric in form, it may be trued by placing the point of a new 10-inch or 12-inch coarse file on rod R-39, P-14 (using the rod merely as a rest) and bearing lightly on top of friction material with motor running.

CAUTION.—In doing this, be very careful to hold the point of the file perfectly flat on the rod, since if you hold it at an

angle you will get the face of the leather ground off on a slant and it will then not fit the disc wheel squarely.

INSTRUCTION NO. 2.—New friction material may be ordered from the Nicholas Power Company, Incorporated, at any time. The old material may be removed by loosening the set screw in the hub R-16, P-14, and in set collar R-21, P-14, and in R-24, P-14. Having done this, R-25, P-14, may be pulled out to the right, thus releasing the friction wheel. You can then take out the old friction material by removing the screws in the face of R-16, P-14. The process of reassembling is the reversal of the process of dis-assembling, but

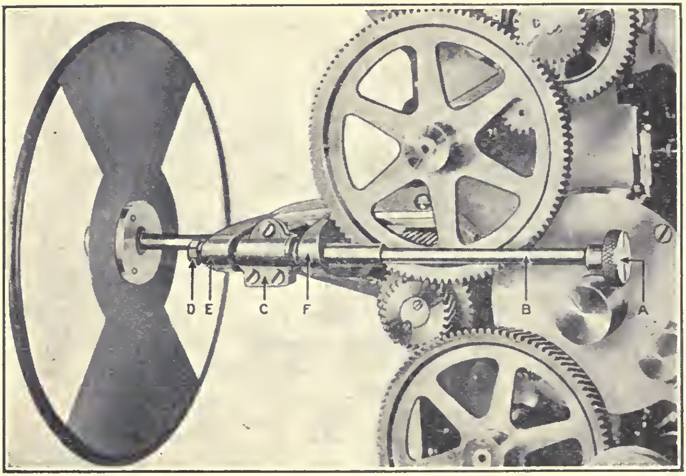


Figure 249.
Power's Adjustable Shutter Bracket.

these parts run on high speed, therefore, be sure and set up all the screws tight.

INSTRUCTION NO. 3—CAUTION.—Never leave the controlling lever down when the projector is standing still; always pull the lever clear up so as to disengage friction wheel R-15, P-14, from driving disc R-13, P-14. Failure to attend to this matter will probably result in flat spots on the friction material. In nine cases out of ten where flat spots develop it is caused through failure to heed this warning.

INSTRUCTION NO. 4—TENSION.—It is, of course, necessary that there be sufficient tension, or friction between material R-15 and driving disc R-13, P-14, to drive the projection mechanism, but anything more than sufficient to accomplish this purpose will merely result in undue wear of the friction disc, friction material and unnecessary consumption of power in the motor. The tension or amount of friction between friction material R-15 and friction disc R-13, P-14, is regulated by thumb screw R-32, P-12. Proceed as follows:

Loosen lock nut R-33, P-12, and loosen up on tension screw R-32, P-12, until friction material R-15 and disc R-32 are out of contact. Now, start your motor running and having set the controlling lever down so that the friction driving wheel is pretty well in on the friction disc, slowly tighten up on tension screw R-32, P-12, until the projection mechanism at-

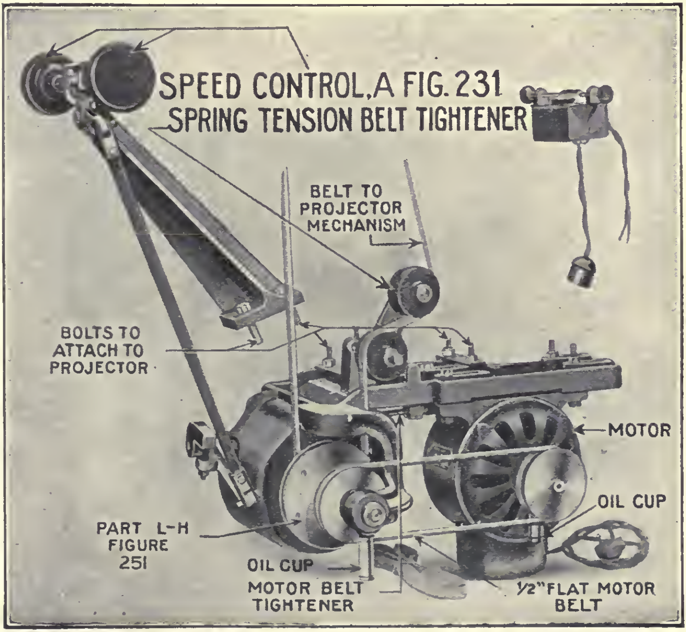


Figure 250.

tains full speed, and you are satisfied there is no slippage between the friction disc and driving wheel. Having done this, your tension will be just right, provided, of course, you have followed the instructions carefully, and have set up screw R-32 just sufficient to bring the projector up to full speed, this being done, of course with the film in the machine, or in other words, under actual operating conditions. After the proper adjustment has been obtained, do not forget to tighten up lock nut R-33 tight, or else the adjustment is likely to work loose.

INSTRUCTION NO. 5.—Grease cups (two of them) should be kept filled with some good lubricating grease (not oil, but grease), which may be obtained from any automobile supply store. The commutator of the motor may be reached by opening the two latticed cast-iron doors on the upper end of the motor.

INSTRUCTION NO. 6.—The motor may be disengaged merely by removing bolts R-6, P-13, and disconnecting its cable. When putting the motor back, be sure and line the

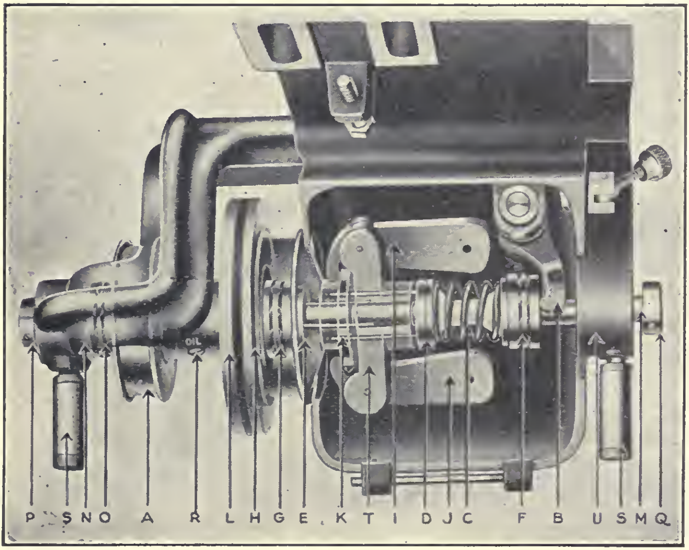


Figure 251.

shaft of the motor directly with the friction driving shaft R-25. If you don't do this, there will be trouble and probably more or less noise. In fact, should the device develop noise at any time, and you find that the friction wheel material is true, the next thing to look at is the alignment of these two shafts; it being possible that bolts R-8 worked loose and let the motor get out of alignment with the driving shaft R-25.

INSTRUCTION NO. 7—NO OIL.—With the exception of the motor bearings, none of the other bearings of this device require any lubrication whatever, this by reason of the fact that the bushings are all of material which requires no lubricaton.

THE POWER'S ADJUSTABLE SHUTTER BRACKET.—This is a very simple device by means of which the revolving shutter may be "set" or "timed," within certain limits, while the projector is running. It is illustrated in Fig. 249. The main advantage this device presents from the viewpoint of the projectionist, is that it is only necessary to set or time his shutter approximately correctly in the usual way, since he can make the finer adjustment by means of knob A after the projector is working. Instructions No. 28 and 32 contain matter concerning this bracket.

POWER'S FRICTION TYPE, GOVERNOR-CONTROLLED SPEED CONTROL.—This type of speed control is illustrated, as a detached unit, in Fig. 250. It is shown attached to the projector in Fig. 231. Its internal mechanism may be examined in Fig. 251. Fig. 250 is very largely self-explanatory.

Examining Fig. 251, shaft M has a collar, P and Q, on either end, and runs in bearings N and U. All parts between pulley A and part B, including ball bearings F, G and O, are mounted upon but are in nowise attached to shaft M. By this we mean that they simply use shaft M as a spindle upon which to revolve.

The action is as follows: The driving motor is attached directly to pulley A, Fig. 251, by means of an endless, flat, half-inch belt, as shown in Fig. 250. This pulley and part L form one part and revolve as a unit, part L being faced with a disc of friction material attached thereto by screws.

Part B is a fork which connects directly with and is controlled by knob A, Fig. 231. Ball bearings F, G and O act entirely as thrust bearings. They are not bearings within the ordinary meaning of the term. Their office is to carry the end thrust, which is the basic principle upon which the control operates.

HOW IT WORKS.—When speed control knob A, Fig. 231, is in position to stop the projector mechanism, it has moved fork B away from thrust ball bearing F, and has thus relieved spring C of all compression. This eliminates all friction between discs L and H. When knob A is in position to start the projector mechanism, it has caused fork B to shove bearing F endwise, which has the effect of compressing spring C and bringing discs L and H together under pressure, which will, of course, cause part L and pulley W to revolve, and thus drive the projector mechanism, pulley W being a part of disc H.

Understanding that pulley A and disc L are one piece, that pulley W and disc H are rigidly joined, and that both revolve freely on shaft M, pulley A being belted direct to the motor and pulley W direct to the projector mechanism, it will be seen that when discs L and H are pressed together by coil spring C, the projector mechanism will be driven by the friction set up between the two discs. That much is quite plain and simple.

THE GOVERNOR.—And now let us examine governor T, Fig. 251, and see what it is for. At any given speed of projection the "load" which must be pulled by the friction between discs L and H will require a certain, fixed amount of pressure by spring C to carry it. It will also be seen that exactly in proportion as projection speed is increased, the amount of the load to be pulled is increased, because increase in speed always requires an increase in expenditure of power.

When the projector is started, the entire force of spring C will be exerted to press friction discs L and H together, and the amount of driving force available will depend upon how much the spring is compressed, which in turn depends upon the position of speed control knob A, Fig. 231. As soon as disc H starts to revolve, however, the governor also starts to revolve, and governor arms J, Fig. 251, are thrown outward by centrifugal force. If you examine these arms you will see their ends are hooked, and that the hooks bear upon collar K, against the other end of which spring C presses. It therefore follows that any force exerted by arms J will act to compress spring C, hence to lessen the friction between discs L and H.

As speed is increased, the power exerted by arms J becomes greater, which, of course, means that they are carrying an increased amount of the pressure exerted by spring C, and in this way friction between the discs is decreased with increased speed until a point is reached where there is just enough left to carry the load at the speed knob A, Fig. 231, is set for, the difference between the speed of discs L and H being accounted for in slippage.

All this is very simple, once you understand it. We therefore recommend that you study the foregoing carefully.

TO DISASSEMBLE THE CONTROL.—All that is necessary to be done when taking the governor type speed control apart is to first let down the cover, which may be done by slipping out the latch holding it in place, and then loosen the set screw in collar P, slip the collar off the shaft and, holding the hand under the entire moving parts of the control, pull the shaft M out to the right, when all the parts will come away in the hand. When reassembling the parts great care should be exercised that they all be placed on the shaft in exactly the same position as before. The covered position of the various parts may be readily seen by referring to Plate 251.

OILING THE CONTROL.—This type of control does not lose its efficiency through oil coming in contact with any of the frictional surfaces, therefore oil may be applied to all parts without fear of making the control inoperative. A medium weight machine oil should be employed to lubricate all moving parts of the control, including the ball thrust bearings.

Particular pains should be taken to see that screw R, Fig. 251, is removed occasionally and oil forced into the oil hole, in order that the lubricant may reach the shaft M at the point upon which parts AL revolved. Also, as often as may be necessary, cup grease should be placed in oil cups S. These oil cups are wick oilers, and **only a light grade of cup grease should be used.**

SUPPLY PARTS FOR NO. 6A AND NO. 6B MECHANISMS

Stock—Order Parts By Number

No.	Name	No.	Name
601	Main Frame	613	Large Top Roller
602	Top Frame including Thumb Screws	614	Large Top Roller Spindle
603	Framing Carriage (Casting Only)	615	Large Top Roller Bracket Spring
604	Top Frame Supporting Rod (2)	616	Large Top Roller Collar
605	Stereo Support Bracket	617	Top Sprocket
606	Stereo Support Bracket and Rod	618	Top Sprocket Spindle
607	Stereo Collar	619	Top Sprocket Feed Gear (large)
608	Stereo Lens Rod	620	Top Sprocket Feed Gear (small)
609	Small Top Roller	621	Pinion for Automatic Shutter Spindle
610	Small Top Roller Spindle	622	Spindle for Automatic Shutter
611	Set Collar for Small Top Roller		
612	Top Roller Bracket		

Stock—Order Parts By Number

No.	Name
623	Friction Case Cover for Automatic Shutter (Outside)
624	Friction Case Cover for Automatic Shutter (Inside)
625	Friction Shoe with Spindle for Automatic Shutter
626	Friction Weight for Automatic Shutter
627	Lever for Automatic Shutter
628	Link for Automatic Shutter
629	Apron for Top Tension
630	Crank Shaft Driving Gear
631	Crank Shaft
632	Crank with Handle Complete
633	Small Gear Meshing in Driving Gear
634	Large Gear for Front Shutter
635	Small Gear for Front Shutter
636	Spindle for Front Shutter
637	Bracket for Front Shutter
638	Set Collar for Front Shutter Spindle (2)
639	Lens Adjuster
640	Large Idler Gear
641	Large Idler Gear Spindle
642	Large Idler Gear Set Collar
643	Take-up Feed Driving Gear
644	Take-up Feed Pulley
645	Take-up Feed Spindle
646	Take-up Feed Sprocket
647	Framing Device Clamp
648	Framing Device Lever Socket
649	Framing Device Lever Socket Link
650	Framing Device Lever
651	Framing Device Screw
652	Framing Device Nut
653	Take-up Roller Bracket
654	Bearing for Large Idler Gear Spindle
655	Take-up Roller Spindle
656	Set Collar for Small Spindle
657	Take-up Roller
658	Take-up Roller for Bracket Spring (large)
659	Intermittent Roller Bracket
660	Intermittent Roller
661	Intermittent Roller Bracket Spindle
662	Intermittent Set Collar for Shaft
663	Intermittent Spring
664	Stud for Intermittent Roller Bracket
665	Take-up Roller Bracket Spring
666	Pin Cross and Intermittent Spindle
667	Intermittent Sprocket
668	Oil Tube and Cap for Large Idler Gear Spindle Bracket
669	Apron Complete with Rollers
670	Intermittent Bushing (large)
671	Intermittent Bushing (small)
672	Flywheel
673	Oil Cup for Intermittent Movement
674	Cover for Intermittent Movement
675	Cam and Spindle for Intermittent Movement
676	Collar for Intermittent Cam Spindle
677	Pinion for Flywheel
678	Toggle Joint Gear
679	Toggle Joint Idler Gear Spindle

No.	Name
680	Driving Gear for Idler
681	Driving Gear Spindle
682	Connecting Link
683	Small Horizontal Lever
684	Large Sliding Guide
685	Small Sliding Guide
686	Stud for Horizontal Lever (2)
687	Aperture Plate
688	Front Plate
689	Gate
690	Hinge for Gate
691	Guide Roller (2)
692	Guide Roller, Bushing, Spring and Spindle
693	Latch for Door
694	Tension Shoe
695	Gate Hinge Pin
696	Cooling Plate
697	Flap for Automatic Shutter
698	Rock Shaft for Automatic Shutter
699	Carriage Guide Rod (2)
700	Outside Revolving Shutter Blade
701	Outside Revolving Shutter Bushing (large)
702	Outside Revolving Shutter Bushing (small)
703	Outside Revolving Shutter Flange
704	Stereo Support Rod
705	Upper Film Shield
706	Lower Film Shield
706a	Light Shield for 706
707	Spindle for Lower Film Shield
708	Lower Film Shield Bracket
709	Flywheel Spindle Screw
710	Upper Roller Bracket Screw
711	Key for Intermittent Cam Spindle
712	Adjuster for Tension Shoe
713	Set Collar for Carriage Guide Rod
714	Lens Ring
715	Tension Spring for Tension Shoe (2)
716	Lower Film Shield Spring
717	Spring for Friction Shoe for Automatic Shutter (2)
718	Washer for Crank Shaft
719	Take-up Roller Flange (2)
720	Washer for Toggle Joint Gear
721	Latch Spring
722	Guide for Gate Latch
723	Screw for Framing Device Clamp (2)
724	Screw for Top Casting on Main Frame (2)
725	Screw for Bearing for Large Idler Gear Spindle (2)
726	Screw in Top Casting for Stereo Support (2)
726a	Cap screw for Stereo supports No. 605 and 606
727	Screw for Fastening Large and Small Sliding Guides
728	Stop Screw and Nut for Loopsetter
729	Stop Screw and Nut for Gate
729a	Stop Stud for New Style Gate
730	Screw for Motor Attachment on Frame (3)
731	Screw for Connecting Link

Stock—Order Parts by Number

No.	Name
732	Screw to hold cooling plate to gate (2)
732a	Screw to set Tension on Cooling Plate
733	Screw to tighten Take-up Roller Bracket Spindle
734	Screw for Apron for Top Tension (2)
735	Screw for Aperture Plate (4)
736	Screw for Set Collar on Top Roller
737	Screw for Tension Spring (2)
738	Screw for Tension Shoe Angles
739	Screw for Outside Shutter Spindle Collar
740	Screw for Friction Case Cover
741	Stud for Framing Carriage
742	Washer for Flywheel
743	Screws for small and large intermittent bushings 670-671 (2)
744	Screws and nuts (2) for guide casting 684
745	Angles for tension shoes
746	Screw and nut for adjusting intermittent roller bracket
747	Screws for gate hinge (3)
748	Screws for lower apron (2)
749	Screw and nut for adjusting take-up roller bracket
782	Screws for upper and lower sprockets
783	Screws and nuts for upper film shield (2)
784	Screws for front plate (4)
785	Thumb screws for top frame (2)
786	Washers for thumb screws 785 (2)
787	Screw to hold shutter bracket in position
788	Front screw for tightening shutter bracket
789	Taper pin for crank shaft (crank end)
790	Screws for outside revolving shutter bushing (large) (2)
791	Screws for outside revolving flange (3)
792	Screws (2) for fastening loopsetter bracket to frame
793	Screws (3) for intermittent casing cover
794	Spring for guide roller spindle
795	Screws (2) for upper, intermittent and lower bracket springs
796	Screws (2) for bearing of shaft 641
797	Gate latch screw and nut
798	Screw for lower 628
799	Screw for crank

MOTOR ATTACHMENT PARTS

No.	Name
750	Main Bracket
751	Large Shaft
752	Small Shaft
753	Large Gear
754	Small Gear
755	Pulley
756	Washer for Intermediate Gear
757	Intermediate Gear
758	Washer on Main Mechanism Frame
759	Nut on Main Mechanism Frame

LOOPSETTER PARTS

No.	Name
760	Roller Spindle
761	Cam
762	Pulley Gear
763	Pin in Fork for Cam
766	Clutch
767	Bearing
768	Fork, complete with Pin
769	Roller
770	Roller Washer
771	Clutch Pin (short)
772	Clutch Pin (long)
773	Arm Spindle
775	Stud for Bearing
776	Clutch Pin on Fork (2)
777	Pulley Washer
778	Set Screw for Arm
779	Set Screw for Cam (2)
780	Arm
781	Tension Spring

PARTS FOR MOTOR AND MECHANICAL SPEED CONTROL FOR NO. 6A AND NO. 6B CAMERAGRAPH

Please order by number

No.	Name
R-1	Base
R-2	Adjustable Support Bracket
R-3	Hexagon Head Bolt for Elevation Block (4)
R-4	Adjustable Support Bracket Bolt (4)
R-5	Base Support Hexagon Head Bolt for No. 6A (4)
R-6	Motor Support Screw Nut (4)
R-7	Guide Rod Set Screw (8)
R-8	Motor Support Screw (4)
R-9	Motor Support Screw Washer (4)
R-10	Bell Crank Stud
R-11	Sliding Carriage Adjusting Screw (2)
R-12	Controlling Lever Spring
R-13	Friction Disc and Shaft (not sold separately)
R-13a	Hardened Pin for R-13
R-14	Friction Pulley Washer
R-15	Friction Pulley Driving Diso
R-16	Friction Pulley Hub
R-17	Grooved Belt Pulley
R-18	Sliding Carriage
R-19	Friction Pulley Shaft Washer
R-20	Stop Collar
R-21	Set Collar
R-22	Universal Flange
R-23	Motor Shaft Coupling
R-24	Friction Pulley Shaft Coupling
R-25	Friction Pulley Shaft
R-26	Controlling Lever Pivot Screw
R-27	Bushings (4) non-oiling
R-28	Controlling Lever Spring Screw (2)

Stock—Order Parts By Number

No.	Name
R-29	Controlling Lever Pawl
R-30	Controlling Lever Pawl Pivot Screw Nut
R-31	Controlling Lever Pawl Pivot Screw
R-32	Thrust Screw
R-32a	Hardened Pin for R-32
R-33	Thrust Screw Lock Nut
R-34	Controlling Lever Washer
R-35	Bell Crank Link
R-36	Bell Crank Screw
R-37	Washer for Elevation Block Hexagon Bolt (4)
R-38	Nut for Washer for Elevation Block Hexagon Bolt (4)
R-39	Guide Rod (2)
R-40	Lever Link Stud Washer (cotter pin end)
R-41	Lever Link Nut Washer
R-42	Lever Link for Stud Cotter Pin
R-43	Lever Link for Stud for No. 6A
R-44	Lever Link Stud Nut
R-45	Lever Link Coupling Stud (Link End)
R-46	Lever Link Coupling Stud (Bell Crank End)
R-47	Ratchet Bolt Washer (2)
R-48	Ratchet Bracket Bolt (2)
R-49	Ratchet for No. 6A
R-50	Controlling Lever
R-51	Lever Link Coupling for No. 6A
R-52	Lever Link for No. 6A
R-53	Bell Crank
R-54	Block (extension)
R-55	Ratchet for No. 6B
R-56	Ratchet Bracket for No. 6B
R-57	D. C. Motor Frame
R-58	D. C. Motor Armature (110 volt)
R-58	D. C. Motor Armature (220 volt)
R-59	D. C. Motor Cover with Screeen (2)
R-60	D. C. Motor Connector
R-61	D. C. Motor Hood
R-62	D. C. Motor Oil Cup
R-63	D. C. Motor Rear End Housing
R-64	D. C. Motor Brush
R-65	D. C. Motor Brush Holder (right)
R-66	D. C. Motor Brush Holder (left)
R-67	D. C. Motor Bearing
R-68	Motor Spring
R-69	D. C. Motor Spring Wick
R-70	D. C. Motor Commutator (110 volt)
R-70	D. C. Motor Commutator (220 volt)
R-71	D. C. Motor Front Housing
R-72	A. C. Motor Frame
R-76	A. C. Motor Hood
R-74	A. C. Motor Oil Cup
R-75	A. C. Motor Connector
R-76	A. C. Motor Hood
R-77	A. C. Motor Rotor
R-77c	Shaft for R-77
R-78	A. C. Motor Bearing
R-79	A. C. Motor Spring
R-80	A. C. Motor Spring Wick
R-81	A. C. Starting Switch
R-82	A. C. Starting Switch Fingers (2)
R-83	A. C. Motor Starting Switch Pin (2)
R-84	A. C. Motor Starting Switch Spring (2)
R-85	A. C. Motor Starting Switch Insulator Washer
R-86	A. C. Motor Collector Ring
R-87	A. C. Motor Rear End Housing
R-88	Screw for Friction Pulley Washer (4)
R-89	Screw for Ratchet Bracket for No. 6B (2)
R-90	Base Support Hexagon Head Bolt for No. 6B
R-91	Base Support Hexagon Head Bolt Nut
R-92	Lever Link Coupling for No. 6B
R-93	Lever Link Stud for No. 6B
R-94	Check Rod for Pawl
R-95	Lever Link for No. 6B
R-96	Screw for Ratchet Bracket No. 6B (2)
R-97	Screw for Adjustable Support Bracket

MUSCLE IS CHEAP.
USE YOUR BRAINS.

The Simplex Projector

THE Simplex projector is made in two models, known as the "Regular" and the "Type S." The only difference between the two is the construction and equipment of the lamphouse. The "Type S" is the projector herein described. The mechanism instructions for both models are identical.

The Type S lamphouse is constructed of heavy Russian iron. The doors (one on each side) are double walled, with a half-inch air space between the walls through which a current of air passes constantly. The general ventilation of the lamphouse is excellent.

Fig. 253 illustrates the Type S lamphouse. Its dimensions are: Front to back, 26 inches; width, 13.5 inches; height from floor to top, 27 inches.

At the top is a vent, so arranged that connection may be made with a pipe leading either to the outer air or to the projection room vent flue. The maximum possible distance center of condenser can be placed from aperture is 19 inches, the minimum 10 inches. As shown in Fig. 253, the condenser casing swings outward on hinges to allow the projectionist quick and convenient access to the lenses for cleaning or replacing. The casing is locked rigidly in place by moving a single lever. Each lens is carried in a cast iron ring, and is retained therein by a threaded collar. These rings act as a heat and cold reservoir, equalizing the expansion and contraction of the thin edge and thick center of the lenses. The arrangement is an excellent one, but we would recommend the purchase of at least one extra ring, so that an extra collector lens, or even an extra collector and an extra converging lens, may be mounted in rings, all ready for instant installation in case of necessity.

CAUTION.—When placing lenses in the rings do not screw the retaining collar down too tight. Leave it just a little bit slack, else there will be no room for expansion, and the lens may and probably will bind and break. The ring and the threaded collar are shown in lower corner of Fig. 253.

Type S lamp is illustrated in Fig. 254. It is of rugged, rigid construction. It, of course, has all the necessary, usual adjustments. The carbon jaw holders are carried by two ½ inch steel bars placed 3¼ inches apart. Between them is a very coarse threaded screw by means of which the carbons are fed together. Its pitch is such that one turn alters the distance

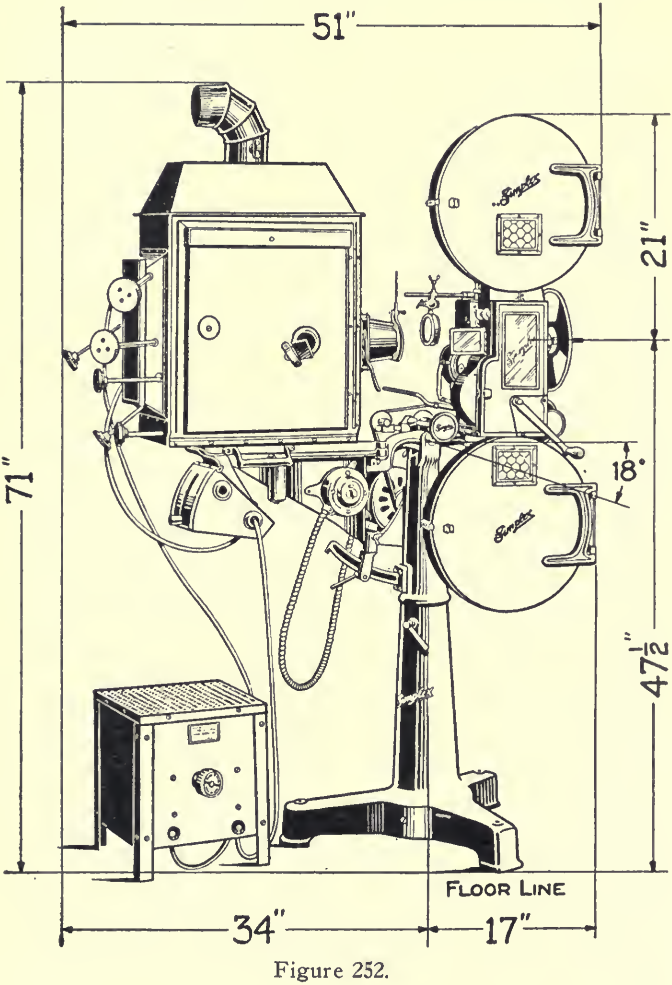


Figure 252.

of carbon tips 3/8ths of an inch. The carbon contacts are one inch deep, and the clamping device is a powerful one. The top carbon is clamped in the jaws by a ½ inch bolt, and the bottom clamping bolt is ⅜ inch in diameter. The arrangement is excellent, both by reason of size of bolts and because the nuts are four inches away from the arc.

The wire terminals are something like seven inches from the arc and of very ample dimensions. The device by means of which the wire is clamped insures perfect electrical con-

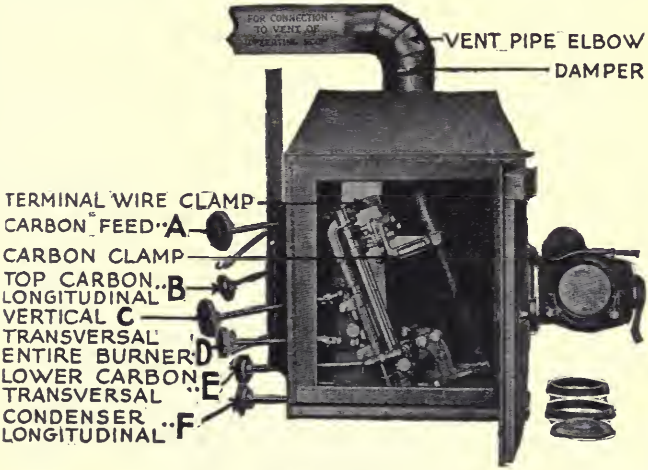


Figure 253.

tact. The insulation is so arranged that there is slight danger of carbon dust forming grounds. The whole lamp is heavy, rigid and well designed.

INSTRUCTIONS ON SIMPLEX MECHANISM

NOTE.—While these instructions may seem complicated, they really are quite simple. If they are followed carefully and accurately the projectionist will have little trouble in their successful application.. "P.I, "P.5," etc., means Plate I, Plate 5, etc. Reference to general instructions means the instructions beginning on Page 592, which apply to all projectors alike.

INSTRUCTION NO. 1. TO REMOVE FILM TRAP GATE, OR DOOR, A, P.2.—First shove knob S-134-E, P.2, in as far as it will go, which places gate or door in position shown in

P.2. Next lift up on gate, which should readily disengage from its holding pins. If it sticks so you cannot move it, set a stick of hardwood against its lower outside corner and tap gently with a hammer until it starts, whereupon it may be lifted out.

CAUTION.—Attached to lower end of gate or doors is the shoe or cradle which acts as idler to the intermittent sprocket. Under no circumstances apply pressure to this in an attempt to disengage the door or gate. If you do you may and probably will bend it, which means trouble. See Instruction No. 31.

INSTRUCTION NO. 2—TO REMOVE INTERMITTENT MOVEMENT COMPLETE AS A UNIT.—First remove knurled screw S-209-G, P.3, and pull the gear it holds in place off its spindle. Pull curved part of mechanism casing cover D-9, P.6, down, and lay a weight on it to keep it down out of the way. Open gates or door by pushing knob S-134-E, P.2, inward, thus preventing its interference with intermittent sprocket when you pull unit out. Loosen retain-

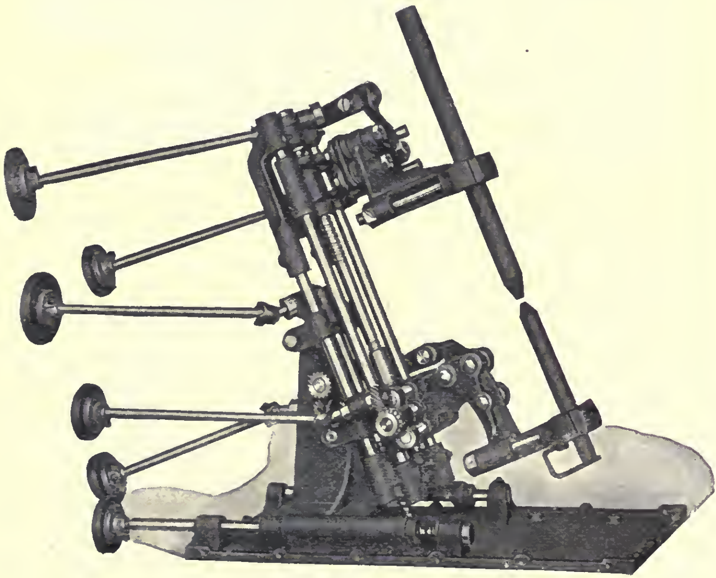


Figure 254.

ing screws S-157-B, P.2, (two of them) and shove locking ears they hold aside so they no longer engage with holding ring. Turn flywheel until set screw in collar C-192-G, P.2, faces lamphouse, then loosen screw and take collar off shaft. You may now pull the entire intermittent unit (which includes flywheel, intermittent oil casing and intermittent sprocket), together with gear G-133-G, P.3, out on the flywheel side, grasping flywheel with right hand and gear with the left.

INSTRUCTION NO. 3—TO REPLACE INTERMITTENT UNIT.—This requires very careful work and an exact following of the instructions supplied. The operation is simple enough, but due to the fact that the intermittent casing must, in the very nature of things, fit into its holding ring accurately, it is quite possible to, by carelessness, or even by a comparatively slight error in procedure, do very serious damage to the parts. We therefore advise you to study the instructions carefully, and to **follow them exactly.**

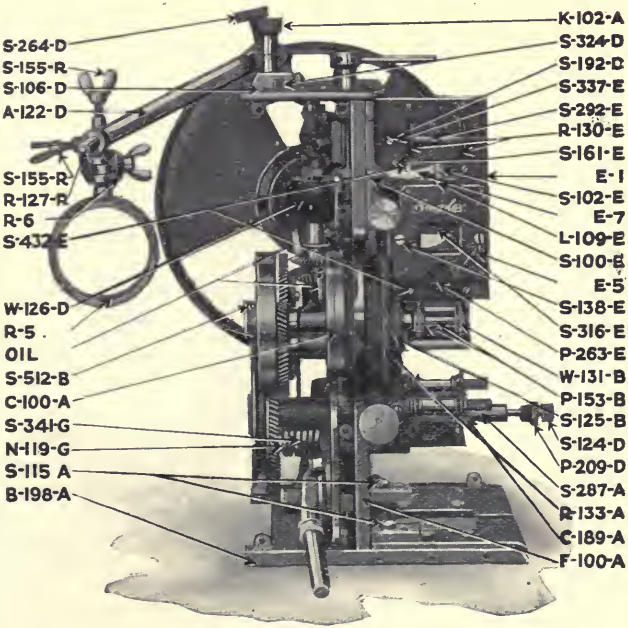


Plate I, Figure 255.

Hold intermittent unit in your right hand, by its flywheel. Mesh teeth of gear G-133-G, P.3, with teeth of small gear attached to inner surface of flywheel and, holding large gear in left hand, shove intermittent casing into opening A-7, P.4, at the same time entering shaft (S-444-G, P.4) of large gear into its bearing. Shove both gear and casing into place at one and the same time, being very sure dowel pin on framing can engages properly with hole in intermittent casing.

TAKE NOTICE.—It is essential to smooth running that the teeth of gear G-133-G, P.3 and the small gear it meshes with on flywheel shaft, be in the same relation to each other they were before they were separated. In other words the same teeth must be engaged that were engaged before disassembled. On outer rim of the large gear you will find stamped a cipher (0), and another on the rim of the flywheel, unless you have an old model mechanism, in which case you should turn

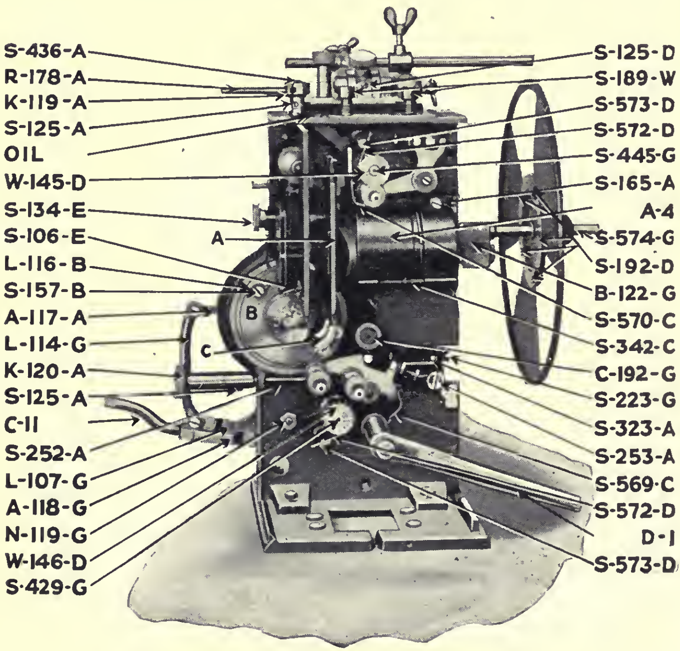


Plate 2, Figure 256.

flywheel until large end of pin in hub of gear on vertical shaft just under governor weights points straight out, and make a scratch mark on rim of large gear exactly opposite end of pin and another at edge of flywheel.

After intermittent unit and gear are in place pull intermittent casing out just far enough so that the two gears disengaged, and if the 0's are present, turn gear and flywheel until the "0" on each is in line with the other, whereupon mesh the gears. Then pull both gear and casing out until large gear disengages from gear on vertical shaft. You now have gear G-133-G, P.3 meshed with gear on flywheel shaft correctly, but not engaged with gear on vertical shaft, which is the second gear below governor weights on the shaft.

Turn flywheel and gear G-133-G until the "0" is exactly opposite center of vertical shaft, and turn vertical shaft until big end of pin is opposite the "0", whereupon shove the casing and gear home, put collar on opposite end of shaft of gear G-133-G, replace gear G-112-G, P.3, and its retaining screw, being very sure the clutch faces on shaft of gear G-112-G, P.3, engage properly.

NOTICE.—Unless these clutch faces or shoulders do engage properly, the gear will not go clear on and the teeth of the two gears will not engage their full width

Next engage locks L-116-B, P.2, (two of them) with rim or flange of framing cam, tighten their holding screws and the job is done.

INSTRUCTION NO. 4—ADJUSTMENT TO ELIMINATE LOST MOTION IN INTERMITTENT SPROCKET.—See general instruction No. 5, and study it. Remember that this adjustment is usually made when the mechanism is cold, and that the parts will expand through the normal heat of operation, which includes some heat from the "spot," which is carried through the metal. Therefore always make the test for lost motion in the intermittent sprocket immediately after running a reel.

First turn flywheel until intermittent sprocket stops, and then about a quarter of a turn more. You then know the movement or the star is "on the lock," as it must be for this adjustment. In the hub of the intermittent casing, B, P.2 or B-8, P.4, you will find two small screws. Loosen, but do not remove them, after which apply wrench end of Simplex spanner wrench, or some other suitable wrench to the hexagon nut between the intermittent sprocket and the bushing.

Turn this nut, which is a part of the bushing, one way or the other until excess circumferential play of sprocket is eliminated. When through, tighten the holding screws in the hub and the job is done, but be very careful as to the latter, as the screws have a tendency to clamp the star against the cam, in which case the adjustment made must be slacked off just a little bit. Be sure this does not happen. You can test it by trying the flywheel very gently. If it refuses to turn, or turns hard, then loosen the screws and slack off on the adjustment just a little.

CAUTION.—Do not get the movement too tight. There should be no lost motion in the sprocket, but at the same time the flywheel should turn freely. Before making adjustment, if the projector has been standing still for some time first run it a little to get the parts thoroughly covered with oil.

INSTRUCTION NO. 5—REMOVING AND REPLACING INTERMITTENT SPROCKET.—We do not advise you to

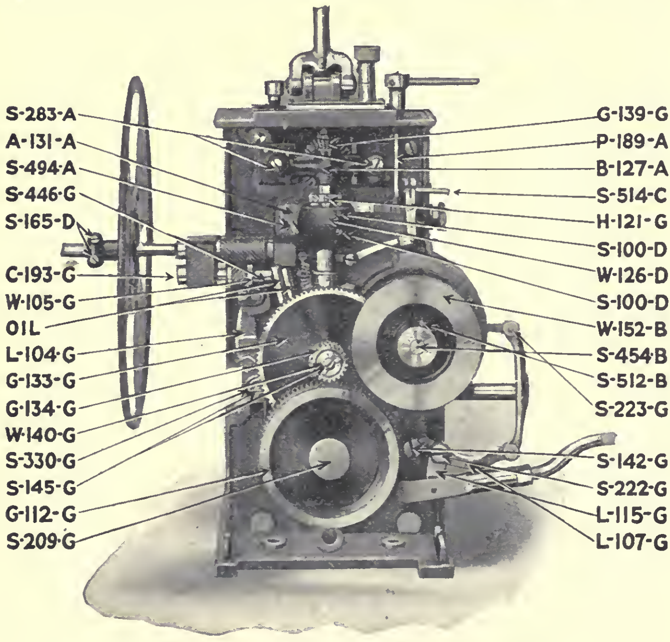


Plate 3, Figure 257.

attempt this, unless conditions compel you to do it. We strongly advise that you purchase an extra intermittent unit. and that when repairs are necessary you install the spare and ship the other to the factory, or to a Simplex distributor for expert attention.

Granted the removal and replacement of an intermittent sprocket is a simple operation, still it is one demanding such extreme accuracy that it is best done at the factory.

To remove intermittent sprocket, first follow instruction No. 2 and loosen the two screws, B, P.2, as for adjusting star and cam, being sure you have them backed off enough to release. You may then, by exerting reasonable force, pull the intermittent sprocket, its shaft, the bushing and the star straight out of the oil casing. To remove sprocket and install a new one see Section C, General Instruction No. 5.

When sprocket is in place on shaft, insert star, bushing, etc., in casing, being very certain that star and cam engage properly, and tighten the two holding screws. To replace intermittent movement unit, see General Instruction No. 2. You will probably have to re-set the revolving shutter; see Instruction No. 36.

INSTRUCTION NO. 6—END PLAY IN INTERMITTENT SPROCKET.—While a very small amount of end play or end movement of intermittent sprocket may do no harm, still there should be none at all. If objectionable end play should develop, which you are unable to trace to any other source, examine the pins which fasten the sprocket to its shaft. It is possible the holes in the sprocket hub have become worn out of oval or egg-shape, in which case the sprocket would have lateral motion equal to the amount of the wear. You can test this by the feel and by examining with a magnifying glass, such as a good reading glass. A condenser lens for a magnifier will hardly serve for this, though you might try it.

If you find the hole to be out of round, then secure from a Simplex distributor, or from the factory, a suitable reamer and, removing the sprocket by following Instruction No. 5 in the matter of taking out the sprocket unit, and using the anvil illustrated in Fig. 225, drive out the pin and ream out the hole in sprocket hub and shaft, being careful to ream out only just sufficient metal to make the hole round. You may then drive in two new pins and reassemble the parts.

INSTRUCTION NO. 7—REMOVING INTERMITTENT OIL WELL CASING COVER.—To remove this part, D, P.2

and B-8, P.4, proceed as follows: First follow instructions No. 2 and 5. In the hub of the casing cover you will find a hole made to receive the pin of the Simplex spanner wrench. By holding the casing stationary and using this wrench you may unscrew the cover, which has an ordinary right-hand thread.

NOTE.—It will be necessary to tap the wrench gently with a small hammer in order to start the part, but remember when doing this that you are working with finely finished parts, made with extreme accuracy, therefore use a little common sense and do not abuse them.

INSTRUCTION NO. 8—REMOVING CAM OF INTERMITTENT MOVEMENT, B-16, P.5.—First follow instructions Nos. 1, 2 and 7. Next remove collar on end of shaft carrying the cam, whereupon you may pull the cam out, together with its shaft and gear.

INSTRUCTION NO. 9—TO REMOVE FLYWHEEL SHAFT, S-454-B, P.3.—First follow instructions Nos. 7 and 8, then loosen set screw in hub of flywheel and pull flywheel and the gear attached to its inner surface off the shaft. The shaft will then drop out of its bearing through the oil well.

INSTRUCTION NO. 10—REMOVING COMPLETE FIRE SHUTTER GOVERNOR UNIT.—The fire shutter governor, W-126-D, P.3, the vertical shaft on which it is mounted, and the gears on the shaft are for all practical purposes one unit. To remove any one of the parts it is necessary to do considerable in the way of preparation. First take off the upper magazine and remove screws which hold top plate of mechanism casing. Next loosen set-screw S-125-A, P.2, and lift off focusing knob K-119-A, P.2. Remove left door link screw and lift off top plate of mechanism casing.

Next follow Instruction No. 2, and then, using a small steel punch, being sure to drive from the small end of the pin, drive out taper pin (it will be a set-screw if you have an old model mechanism) in hub of gear G-120-G, P.4, which is the first gear below the governor weights. Next drive pin out of hub in next gear below. Remove center set screw from upper link holder H-121-G, P.3, which will be a taper pin instead of a set-screw if your projector be an old model.

If you have followed these instructions correctly you have now released all parts mounted on vertical shaft, below its upper bearing, from the shaft and you may now lift the shaft out. Should the shaft stick, line the jaws of a plier with heavy paper or thin sheet copper and, grasping upper end of shaft, using center wall of frame as a fulcrum, start the shaft by prying.

INSTRUCTION NO. 11—TO REMOVE SLIDING GEAR G-116-G, P.4.—This is just under the long gear on revolving shutter shaft, and which slides back and forth when framing. First follow Instruction No. 10. You may then remove both gear and shaft by loosening set-screw in collar C-193-G, P.3, on outer end of shaft, and pulling shaft out to the right.

INSTRUCTION NO. 12—REMOVING GEAR ON REVOLVING SHUTTER SHAFT.—To remove this gear, G-147-G, P.4, loosen set-screw in back end of gear and pull the shutter shaft out. Old model mechanisms have taper pin instead of set-screw. Next remove link screw of casing door and take out upper and lower screws holding left side of

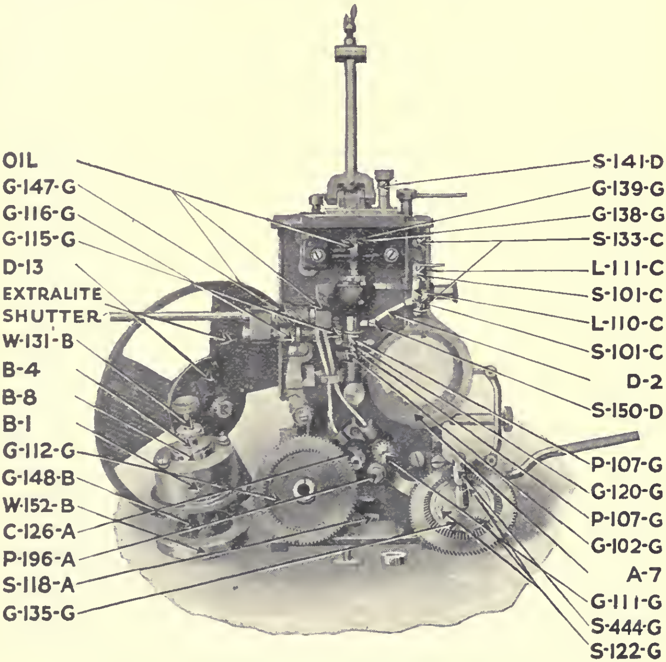


Plate 4, Figure 258.

front mechanism casing, C-152-D, P.6. Remove this part and gear is released.

INSTRUCTION NO. 13—REMOVING REVOLVING SHUTTER BRACKET.—To remove this bracket, which carries revolving shutter gears and shaft, first follow Instructions Nos. 10, 11 and 12. Next remove washer and screw holding framing lever spring S-330-G, P.3, **using extreme care** in so doing, as the spring is under tension and is a very powerful one. **Keep hands away when removing the screw and washer,** then apply blade of screw-driver to back side (side next lamphouse) of end of spring which points toward base. Push outward (toward screen and the spring will release and unwind itself, probably with startling suddenness (which will do no harm), whereupon it may be removed with perfect safety. Provided your mechanism be a late model, you will find a hole in front mechanism cover opposite center wall of frame of mechanism, just over a set-screw. Loosen this set-screw, which will release the stud holding framing slide lever L-104-G, P.3, and pulling stud out will release the lever. If mechanism be an old model and there is no hole by means of which you can reach the set-screw, we would advise you to, using a breast drill and a half-inch drill, make a hole, since otherwise you must remove the entire right hand front mechanism cover. Having removed framing slide lever L-104-G, P.3, you have now only to remove the screws (two of them) holding bracket to frame to release the bracket.

INSTRUCTION NO. 14—REMOVING REVOLVING SHUTTER SHAFT.—To remove the revolving shutter shaft, S-574-G, P.2, it is only necessary to take out set-screw in rear end of hub, G-147-G, P.4. This screw is quite short and has a pointed end which engages with counter sunk hole in shaft. Better (using a small, magnetized screw-driver, if you have one), remove it entirely, but be sure you do not lose it.

INSTRUCTION NO. 15—REMOVING REVOLVING SHUTTER BLADE.—To remove revolving shutter blade from its hub (a very necessary operation in many circumstances), take out ten screws from shutter hub, if old model projector or shutter; or five screws, if late model. This releases blade from spider. In replacing, be sure the word "Simplex" (old style shutter), or the words, "Extralite Cutoff Blade," is directly in line with the heads of set-screws S-165-D, P.3.

INSTRUCTION NO. 16—TO REMOVE SHUTTER ADJUSTING SLIDE BLOCK S-323-A, P.2.—First follow Instruction No. 2, and parts of Instruction No. 13, afterward removing mechanism casing parts C-157-C, C-152-D and C-159-C, all P.6. Next take off top plate, P-207-D, P.6, cf mechanism casing. Remove link screw S-181-D, P.6, and take out the framing slide lever as per instruction No. 13. Next drive out the stop pin near upper surface of lower track the block slides on. Loosen set-screw S-253-A. P.2, and turn shutter adjusting knob K-120-A, P.2, counter clockwise until it disengages from the block, whereupon you may pull the block out.

INSTRUCTION NO. 17.—TO REPLACE FRAMING SLIDE LEVER.—In Instruction No. 13 you were given directions for removing framing slide lever L-104-G, P. 3. Assuming that gear G-112-G, P.2, gear G-133-G, P.3, and the flywheel have been removed (see Instructions 2 and 9 for their removal), first place upper, forked end of framing slide lever in the slot on under side of casting which carries sliding gear G-116-G, P.4, so that the fork engages with block in framing slide. The lever itself is bow-shaped, and the outward bow must be forward—toward the screen. Next shove the stud

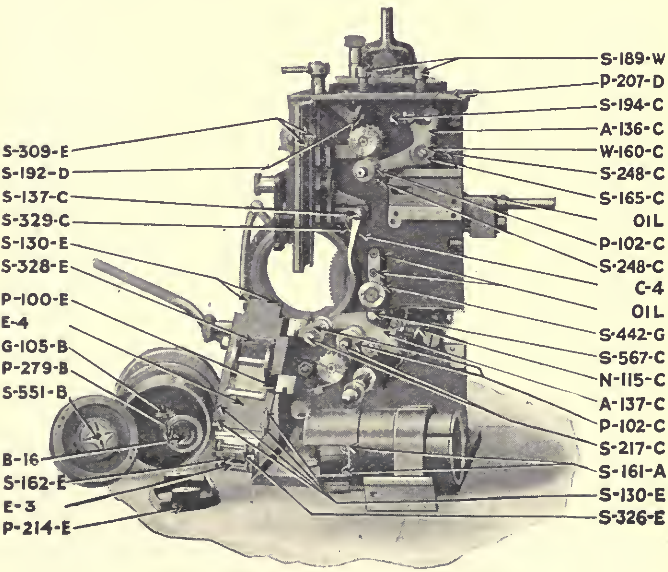


Plate 5, Figure 259.

which holds the lever into place, being certain that set-screw S-223-G, P.2, engages with countersink in shank of stud. Screw set-screw down tight. Place coil spring on stud with the hook upward and toward the lever. Engage the hook with lever. Put washer and screw on end of stud but do not tighten screw down. Leave it quite slack.

In the end of the stud you will have noted a groove. This is to hold the spring when under tension. With the screw slack enough so you can do it, grasp the end of the spring which hangs downward and force it around to the right (clockwise) until it has made approximately one full revolution and points straight downward, whereupon snap it into the groove in end of stud. Hold the spring in this position and tighten the screw in end of stud down solid.

INSTRUCTION NO. 18.—REMOVING SHUTTER ADJUSTING KNOB AND SHAFT K-120-A, P.2—Remove screw and washer which hold lower sprocket idler bracket to its shaft, or stud. Raise bracket away from sprocket and pull it off. Next loosen nuts which are locked together on threaded portion of shaft and, holding the nuts stationary, turn knob K-120-A, P.2, counter clockwise until it releases from sliding block and lock nuts. You may then pull it out.

INSTRUCTION NO. 19.—TO REMOVE FRAMING CAM.—This is the part the framing lever link, L-114-G, P.2, connects to. It is numbered C-100-A, P.1. To remove it, first follow Instruction No. 2. Next remove screw S-223-G, P.3, which connects upper end of link to cam. Take out screws holding back mechanism casing cover, C-151-D, P.6, and remove same. With thumb of left hand shove framing slide lever, L-104-G, P.3, forward (toward screen) as far as it will go and insert a piece of wood about one inch thick between sliding gear, which is under large gear on main shutter shaft, and its bracket, to hold the gear and lever forward where you shoved them. A smaller piece between the lever and its stop will serve as well. The idea is to hold the lever where you shoved it, which relieves pressure of framing slide lever spring, acting through tension block, from edge of cam we are to remove.

Next, using a long, slender-bladed screw-driver, loosen set-screw in framing cam adjusting ring, R-133-A, P.1. This screw locks together the ends of the ring where they are cut. Its loosening unlocks the ring, which may be unscrewed and the framing cam worked slowly around until it is free, when it may be pulled out to the left.

To replace this cam is merely the process before described in reverse, but attention must be given the matter of tightening ring R-133-A, P.1, which must be screwed in far enough to eliminate any possibility of lost motion between the casing and its holding ring, but not tight enough to cause binding during the process of framing the picture.

INSTRUCTION NO. 20.—REMOVING AUTOMATIC FIRE SHUTTER E-7, P.1.—Unscrew the stud with which you raise the shutter, S-514-C, P.3. Remove lever screw, S-100-E, P.1, which is immediately over knob S-134-E, P.2, with which the gate is shoved open, and screw S-102, P.1. When this latter screw is out the fire shutter will drop down and the lever may be pulled out to the right.

NOTE.—If it be an old type mechanism there will be a set-screw instead of the lifting stud, which may be removed after taking off C-151-D, P.6.

INSTRUCTION NO. 21.—TO REMOVE AUTOMATIC FIRE SHUTTER S-316-E, P.1.—Remove link retaining screw S-102-E, P.1, which is the screw by means of which the link at top of shutter attaches to lifting lever. Next remove entire lateral guide roller unit, as per Instruction No. 22, whereupon you may lift the shutter out.

INSTRUCTION NO. 22. TO REMOVE LATERAL GUIDE ROLLER UNIT S-292-E, P.1.—To remove this or any one of its parts, loosen the set screw in its left hand hub and the screw in collar at opposite end. You may then pull shaft out to right, starting it out by prying against its left hand end with a screw-driver blade. The removal of the shaft releases all the parts.

CAUTION.—Before disturbing the unit examine it carefully and be sure you understand how the parts go. There are six of them, viz: a shaft, collar, spacing bushing, two rollers and a coil spring. This guide helps in holding the film central over aperture, hence disturbing the position of any of its parts would have a serious effect.

INSTRUCTION NO. 23.—TO REMOVE GOVERNOR LIFT LEVER D-2, P.4.—It is only necessary to take out the screw in its right hand end, which joins it to the vertical link, and the fulcrum screw S-150-D, P.4. You may then lift the part away.

INSTRUCTION NO. 24.—TO REMOVE FRAMING SLIDE LEVER L-104-G, P.3.—See Instructions Nos. 13 and 17.

INSTRUCTION NO. 25.—TO REMOVE AND REPLACE SPRING MOUNTED ON FRAMING SLIDE LEVER L-104-G, P.3.—See Intructions Nos. 13 and 17.

INSTRUCTION NO. 26.—TO ADJUST FRAMING TENSION.—If the framing handle shows tendency to work up or "creep," there is not sufficient tension. If the framing handle works unduly hard or sticks, the probable trouble is too much tension. Proceed as follows: Remove screw S-209-G, P.3, and pull the large gear it holds off its spindle. Just to the right of and below the spindle you will see a stud on the

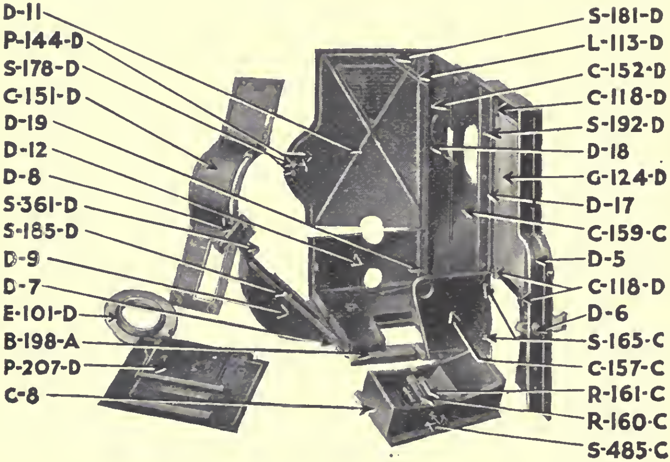


Plate 6, Figure 260.

end of which is two hexagon nuts. Behind these nuts is the coil spring which provides tension for the framing device. Loosen the outer nut, which is merely a lock nut, and tighten or loosen the inside nut until the framing handle works to suit you, after which tighten lock nut again. The nuts are on stud P-196-A, P.4, and the spring is numbered S-341-G, P.1.

INSTRUCTION NO. 27.—TO REMOVE FRAMER TENSION SPRING S-341-G, P.1.—First follow Instruction No. 26, only instead of merely loosening the nuts, remove them entirely and pull the spring off.

CAUTION.—In reassembling be sure and place washer at either end of spring.

INSTRUCTION NO. 28.—REMOVING FILM TRAP COMPLETE.—Should it ever become necessary to remove the entire film trap assemblage, E-1, P.1, as a unit, it may be done by taking out the two large screws S-133-C, P.4, and S-514-C, P.3, which releases the whole thing, but it is best to first remove the door, as per Instruction No. 1, to avoid possibility of damage to intermittent sprocket.

In reassembling it is absolutely necessary that the unit be accurately placed and lined, else the aperture will not be square with the lens. Have the engaging surfaces **perfectly clean.** Place the part in position engaging it with the locating pins and starting the two holding screws, tightening them down, but not solidly. Next (IMPORTANT), with the gate shoved back (open), place a straight-edge of metal, such as a machinist's six inch rule (scale) on the film track, or "trap shoe" as the Simplex folks call it, letting the straight-edge project down past the sprocket. If the part is in line when the straight-edge lies flat on the film track, it will just touch the face of the intermittent sprocket. If the rule rests on sprocket face and is held away from lower end of film track, or if it rests on track but does not touch face of sprocket, tap casting forward or back until track and sprocket face are exactly in line. When this is done, tighten up the two holding screws **tight.**

INSTRUCTION NO. 29.—TO REMOVE FILM TRAP STUD S-134-E, P.2.—This is the thing you shove the gate, or door, open with. To remove it is a simple matter. The knurled knob at its end looks like it is one with the nickeled stud, but it is not. What seems to be a nickeled stud extending into the casting is only a thimble of thin metal covering the steel stud beneath. It is held by the knurled knob. Wrap the knurled knob with either cloth or paper, to prevent marring its surface, and grasping it with a gas plyer unscrew it. It is an ordinary right hand thread. It holds a light, rather long coil spring under compression. The spring is between the nickeled thimble and the stud. Having removed the screw, take off the thimble and spring. You must next follow instruction No. 28 (or you may do this first), after which the stud and entire gate will be released. To reassemble, note reassembling instruction under Instruction No. 28.

INSTRUCTION NO. 30.—REPLACEMENT OF FILM TRACK SHOES.—Film track shoes, S-309-E, P.5, are subject to very heavy wear, and as soon as there is appreciable wear they should be removed and replaced with new ones, otherwise there will very likely be an out-of-focus effect visible from time to time on the screen.

The old type shoes are fitted with beveled edges which slide into a slotted groove in the film trap. To remove, first follow Instruction No. 2, then take out screw holding its upper end, one of which is shown at S-432-E, P.1. Remove guide rollers, as per Instruction No. 22. Remove entire intermittent unit as per Instruction No. 2. This latter is necessary because the part will not slide down past the intermittent sprocket. You may now slide the shoe down and out. The process of reassembling is merely a reversal of the foregoing.

Shoes of late design have four wearing edges. When worn they should shift from right to left, and vice versa. They may then be reversed and the back sides used in the same way. These shoes are released by taking out three small screws, S-432-E, P.1, the heads of which are on front of heat shield, or cooling plate E-5, P.1.

CAUTION.—When installing a new shoe be sure the ends of the screws do not extend through the shoe or protrude on the wearing side. This is especially to be guarded against if the same screws removed from the old shoes are used. If they do, the end may be dressed down, using a very fine file, but great care must be exercised not to mar the guide rollers which protrude through the shoes near their top. It may even be well to, as a matter of precaution, remove the guide rollers, as per Instruction No. 22.

INSTRUCTION NO. 31.—INTERMITTENT SPROCKET IDLER SHOES.—The film is held to the intermittent sprocket by a cradle shoe, held in a steel apron attached to film trap gate, or door. This shoe performs the same office for the intermittent sprocket that the sprocket idlers perform for the other sprockets. The adjustment of the shoe or cradle is of great importance. Examine part C, P.2, and see exactly how it works. Note that the cradle held in the steel apron attached to lower end of gate, or door, is held in place by a flat spring which allows it to adjust itself to the surface of the sprocket, and to move back when a thick splice or a stiff splice goes through.

Note also that the adjustment must be made by observing the relation of the outer tracks of the shoe to the face of the sprocket. The adjustment should be such as will hold the film firmly to the sprocket, without undue friction, at the same time allowing sufficient movement to allow a stiff or thick splice to go through without trouble. In figures the adjustment should be such that when the gate or door is closed the cradle shoe will fit the curvature of the sprocket, and so that the shoe will push back about 1/64th of an inch away from the sprocket face, which is about the thickness of an ordinary business card.

The maintenance of this adjustment is of great importance. It is difficult to tell you just how to obtain it, since it must be done by bending the apron. It is largely a matter of knowing just what is needed (which we have told you) and exercising plain common sense.

INSTRUCTION NO. 32.—REMOVING PROJECTION LENS HOLDER.—Projection lens holder, A-4, P.2, may be removed by taking off the front mechanism casing cover C-159, P.6, and removing screw S-494-A, P.3. The whole tube and sliding block which carries it may then be pulled out.

To adjust lens in holder first loosen clamp screw at front end of top of lens holder. There are several adapters or bushings which fit inside the holder to reduce its diameter to accommodate various diameter lens tubes. Insert the proper adapter, according to the diameter of your lens tube. Strike the arc, and, without any film in, open the automatic fire shutter and block it open. Project the white light to screen. By means of focusing knob rod R-178-A, P.2, on top of mechanism, set lens holder at center of its travel. Then shove lens tube in or out until edges of light on screen are sharply focused, whereupon tighten clamp screw S-165-A, P.2, on top of lens holder. Final focusing will then, of course, be completed with focusing screw after picture is being projected.

NOTE.—When position of lens in holder has been finally fixed, make a scratch mark on lens tube barrel at front end of holder, so that when you for any cause remove the lens it may be correctly replaced by properly locating the mark.

INSTRUCTION NO. 33.—ADJUSTING UPPER AND LOWER SPROCKET IDLER ROLLERS.—The distance of idler rollers from spocket is determined by the adjustment of screws in idler roller brackets, S-194-C and N-115-C, P.5. See General Instruction No. 12.

INSTRUCTION NO. 34.—TO REMOVE UPPER SPROCKET IDLER BRACKET TENSION SPRING, S-570-C, P.2.—You may either remove the entire film trap, as per Instruction No. 28, or move the top plate of the mechanism casing and either make a special tool or secure an offset screw-driver for taking out the two screws at upper end of spring. The spring is the flat steel spring which extends down from the casting which forms the bearing for the upper sprocket shaft. Its lower end curves and engages the end of the idler bracket arm. The two holding screws are right opposite the end of the upper sprocket.

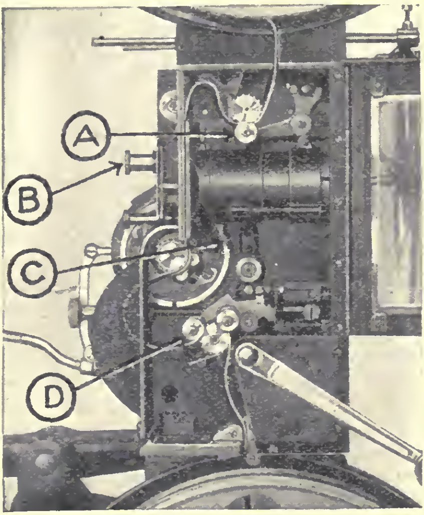


Figure 261.

To replace this spring close the idler up against the sprocket and be sure you tighten the holding screws down solidly.

INSTRUCTION NO. 35.—TO REMOVE THE LOWER SPROCKET IDLER BRACKET SPRING.—It is only necessary to remove one screw. The spring engages with the casting forming the bearing of the main crank shaft. You cannot see the screw when the mechanism casing is in place, but you can feel it. You make take off front casing C-159-C to get at the screw, but by exercising a bit of patience you can remove and replace it, if you make a special screw-driver by breaking off an inch of an old hack-saw blade and grinding one end to a point, or (better) you may secure an offset screw-driver from Simplex distributor. In replacing the screw be sure you set it up tight.

INSTRUCTION NO. 36.—SETTING THE REVOLVING SHUTTER.—See General Instruction No. 22. The blade stamped "Simplex," or in the case of the Extralite, "Extralite Cutoff Blade" is the master blade. General Instruction No. 22 will inform you fully as to the principle involved in shutter setting. Having studied general instruction thoroughly, so as to get a good idea of exactly what it is you wish to accomplish, place framing lever C-11, P.2, in central position, and by means of knob K-120-A, P.2, set sliding block S-323-A, P.2, in the center of its travel, which is midway between the two stop pins in its lower track. Next loosen the set screws which hold the shutter hub to the shaft just enough so you can pull the shutter around by exerting a little force.

Next place a finger of one hand on the intermittent sprocket and turn the flywheel IN THE DIRECTION IT NORMALLY RUNS until a point is reached where the intermittent sprocket just barely begins to move. Move the flywheel back and forth until you determine exactly the point where it starts the sprocket. Now hold the flywheel absolutely stationary and revolve the shutter on its shaft in the direction it normally runs, until the edge of the master is about three-fourths across the lens, which should be right.

Now turn the flywheel VERY SLOWLY in the direction it runs, until the point is exactly reached where the intermittent sprocket ceases to move. If the other edge of the master blade now covers as much of the lens as the other edge did, then the shutter is correctly set. If not, then equalize the two edges as to lens covering, and see instructions for adjusting revolving shutter to local conditions under General Instruction No. 22. When the job is done and a slight travel ghost shows up or down, but only one way, this may be eliminated by slightly altering shutter adjustment by means of knob K-120-A, P.2.

The shutter setting device is operated by knob K-120-A, P.2. It is for the purpose of adjusting the revolving shutter to correct any slight error in timing. The shutter must, however, be first correctly set as per the foregoing instructions.

INSTRUCTION NO. 37.—ADJUSTING GATE TENSION.— See General Instruction No. 9. Correct tension is that pressure which will cause film to begin to overshoot (picture to move up on the screen) when a speed ten revolutions of the crank shaft in excess of your highest projection speed is reached. Anything in excess of this is very bad for both the film and the projector mechanism. To change tension on the Simplex it is necessary to bend the spring which supplies pressure to the tension shoes. This is a curved flat spring, the upper end of which is seen protruding through a slot in the upper side of the lens barrel extension which attaches to the gate or door. It is attached to the door by means of two screws, the removal of which allows it to be lifted out. A magnetized screw-driver should be used for this job. A door should first be lifted off, as per Instruction No. 1. The springs should be bent without removing, but be very sure you bend both sides alike.

INSTRUCTION NO. 38.—The Simplex folks supply, on order, an undersize aperture to be used where it is necessary to eliminate keystone effect by filing. This aperture is about 1/32 of an inch less in size than the regular aperture opening.

INSTRUCTION NO. 39.—TO REMOVE APERTURE PLATE.—To remove aperture plate follow instruction 30, since film tracks must be taken out, then remove projection

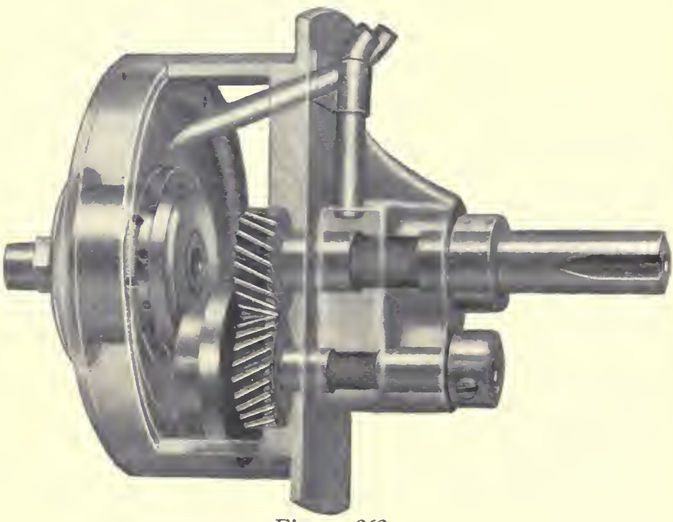


Figure 262.

lens tube by loosening clamp screw S-165-A, P.2, and pulling the lens out. Next, using a proper screw-driver, take out the two small screws which hold the aperture plate in place. They are not seen until the film track shoes have been removed. In replacing aperture, or putting a new one in place, be sure and set the screws up tight, else the plate may be held loosely and scratch the film.

INSTRUCTION NO. 40.—INTERMITTENT MOVEMENT.—In Fig. 262 the intermittent is shown with a part of the oil casing cut away, so that we can see the interior mechanism. The right hand side is the flywheel side. The cam, it will be observed, is the lower member, and is driven from the flywheel shaft by a gearing. What looks like a collar next the flywheel hub is not a collar but a part of the casting, as you may see by looking at your own mechanism. This illustration will be valuable to you when you are following the process of disassembling described in Instructions Nos. 8 and 9.

LUBRICATION.—This is of utmost importance as applies to the intermittent oil well. See General Instruction No. 1 **Use none but perfectly clean oil of good grade.** Under no circumstances use a light oil, such as Three-in-One. Looking at your mechanism, and Fig. 262, note that the oil tube nearest lamphouse carries oil to the oil well, where it ends directly

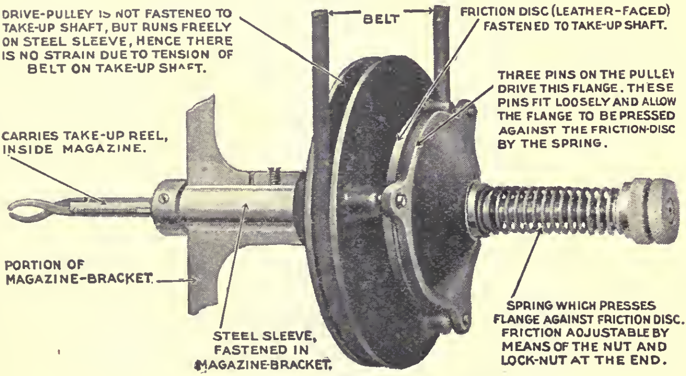


Figure 263

over the star and bushing. The other tube carries oil to the flywheel shaft bearing.

The oil casing should be filled about one-third full of oil. The manufacturer advises against using an oil can to put oil into the oil well, because of the likelihood of dirt getting into the casing. It **recommends the use of a glass syringe,** which may be had at any drug store. The glass barrel enables you to examine the oil before it is put in, and determine whether or not it is entirely free from dirt. Keep the syringe in a box, protected from dust, and wipe the tip clean before using. Small particles of dirt or dust may work serious damage to the closely fitted, highly polished parts.

In **Replacing** old intermittent parts after disassembly, or in installing new parts, **be sure they are perfectly clean.** If they seem to fit too tightly, have patience. These parts are supposed to and must fit snugly. **Never Force** a tight fitting intermittent movement part into place. If you do you probably will ruin the whole thing. If necessary, grind it down, using tripoli or rotten stone mixed with oil for the purpose. **Never Use Emory.** After grinding, wash the parts thoroughly with

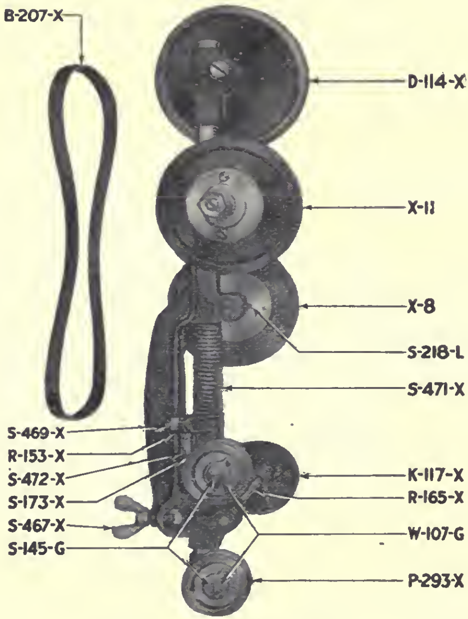


Plate 7, Figure 264.

kerosene or gasoline, and then lubricate with clean oil before inserting.

In Assembling an Intermittent Movement be sure the flywheel or cam shaft fits its bearing without lost motion. If there is lost motion, then send part to service station for attention. If shaft is too tight, grind it in with rotten stone, as before directed. Clean thoroughly with kerosene or gasoline, lubricate and place shaft in position, attaching flywheel to shaft and placing collar on end of cam shaft.

If gears do not run smoothly, then try meshing different teeth. If they cannot be made to run smoothly, then turn flywheel until cam pin is at upper point of its travel, directly under end of oil spout, and using a needle or other sharp instrument, make a mark on the flywheel gear by drawing the needle around the upper circumference of the cam. This is to aid in reassembling the gears after they are disassembled.

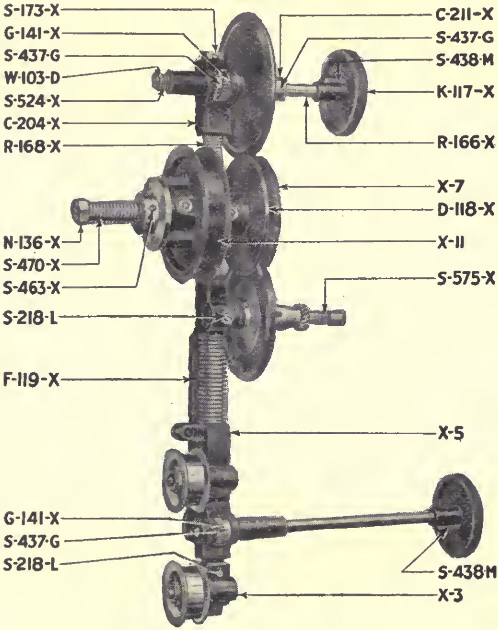


Plate 9, Figure 265.

Next apply to the gear teeth a small quantity of a paste composed of Arkansas powder mixed with oil, and holding intermittent casing with gears down so that the grinding paste will not enter bearings, rotate the flywheel backward and forward until the gears are ground in and run smoothly, whereupon take out the parts and cleanse them thoroughly in a bath of kerosene or gasoline. Repeat grinding process if necessary. In reassembling have shafts and bearings perfectly clean and lubricated with good oil. Be sure gears mesh as they did before, by observing mark you made on face of flywheel gear. If gears grind in spots only, then apply grinding powder to tight spots only.

CAUTION.—These gear grinding, shaft-fitting directions are **not** recommended by us, except under conditions where they are absolutely necessary. Our advice is to have a spare intermittent movement and send the one requiring repairs to a service station or to the factory. We have given them because

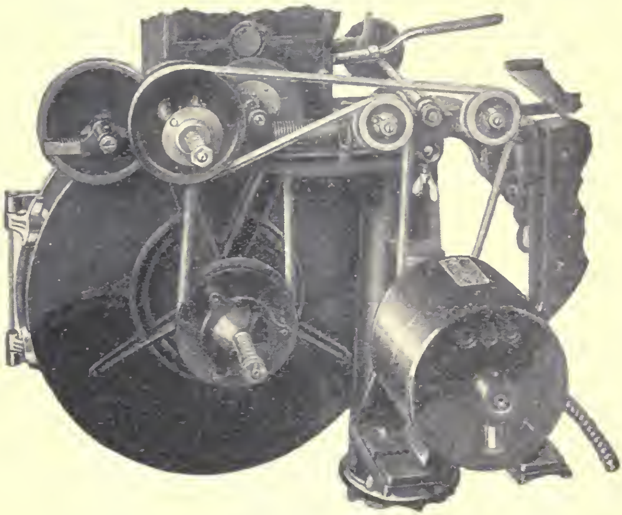


Figure 266.

there are circumstances where the projectionist may be compelled to attempt a repair which will involve these things.

The rotten stone (Tripoli) and Arkansas powder may be had from the Simplex factory or from a Simplex distributor.

THE TAKEUP.—The Simplex takeup is illustrated in Fig. 263. See General Instruction No. 23. The illustration, taken in connection with General Instruction No. 23 seems to supply all necessary instruction.

SIMPLEX SPEED CONTROL.—The control by means of which projection speed is regulated is positive in its action. Its flexibility is such that any speed desired between a minimum of, say, 40 and a maximum of 140 feet per minute may be had.

Examining plates 7, 8 and 9, which are respectively side, top and sectional views of the device, you may readily understand the operating principle, the idea being to cause mechanism driving discs X-8, P.7, to be grasped and driven by friction discs X-7 and D-118-X, P-9, and to provide means by which the projectionist may, by a conveniently located speed adjusting knob, (S-438-M, P.7), either thrust disc X-8 further between the driving discs, in which case it will be driven

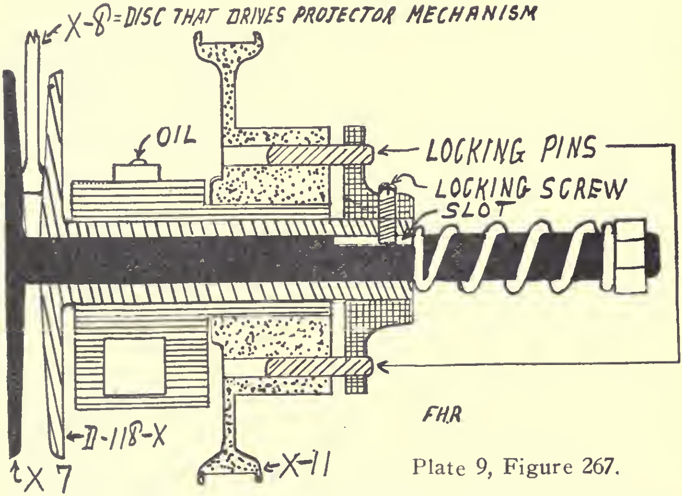


Plate 9, Figure 267.

Bearing carriage whole assemblage, Disc D-118, revolves inside it, and main belt wheel X-11 outside it.

Interior friction disc X-11.

Exterior friction disc and shaft.

Main belt wheel.

Locking washer.

more slowly, or withdraw it further out so that it will be driven more rapidly. All this is readly understood from an examination of the various plates.

The belting arrangement is shown in Fig. 270, spring F-119-X, plate 7, holding the belt, under tension. When the belt stretches and becomes too loose, it may be tightened by loosening the bolts holding motor table and lowering the motor.

OIL.—The two main bearings have oil holes held normally by a spring supported steel ball. To oil, press the balls down with snout of oil can and inject one or two drops of oil. Other bearings have plain, open oil holes.

CAUTION.—Do not get oil on friction discs. If you do, then dip a cloth in gasoline and wash disc X-8 and draw it between the faces of the other discs until all oil is removed. Oil on discs will cause slippage. Keep them clean.

CAUTION.—In Fig. 270 you will observe a hole in which is the end of a shaft. Under the hole is a wing nut. The shaft protrudes from the projector frame casting, in which there is a hole to receive it. Be sure the shaft is in place in the frame casting, and that it is in the hole in the controller casting and clamped by the wing nut, else the control will not set right or be properly supported.

YOU WANT GOOD PAY DON'T YOU? WELL, THEN GIVE GOOD SERVICE—THE BEST THERE IS IN YOU.

Proctor Projector

THE U T E Proctor Automatic Projector is of the fully enclosed pedestal type. By this we mean that the entire mechanism, including the motor and motor drive, is enclosed in a metal casing, only the doors of which are removable. The projector is supported on a pedestal, square in form, 10 inches each way, with a base 19 inches square, as shown in Plate A, Fig. 268. Plate A, Fig. 268, gives the overall dimensions which, when the projector sits in a level position, are 58 inches front to back by 74 inches in height. The lamphouse is 20 inches front to back, 28 inches from its floor to the top of its roof and 10½ inches wide. The mechanism casing is 10½ inches wide by 9 inches front to back, and 15 inches high in the clear, inside measurement.

By means of tilting arrangement, 390, Plate F, the projector may be set to shoot up at an angle of about 15 degrees, or to shoot down at any desired angle not exceeding 35 degrees. By loosening base bolts 700, Plate A (four of them), it is possible to rotate the projector on lower base 555, Plate A. This is to prevent the disturbing of the anchorage of the lower part of base 555, Plate A, in case it is at any time necessary to change the location of the picture sideways on the screen.

With the ordinary side rails, 517-516, Plate A, furnished with the projector, the center of the condenser may be located 21½ inches from the aperture, which is probably all that will ever be required. In case, however, greater distance is necessary, then side rails of greater length may be ordered from the company.

The magazines are 19¼ inches in diameter, inside measurement, the diameter of the 2,000-foot reel being about 15 inches.

IN GIVING THE FOLLOWING DIRECTIONS FOR DISASSEMBLING THE MECHANISM, OR THE REMOVAL OF ITS VARIOUS PARTS, WE HAVE NOT GIVEN THE DIRECTIONS FOR REASSEMBLING BECAUSE REASSEMBLING MERELY MEANS A REVERSAL OF THE PROCESS OF DISASSEMBLING, PLUS COMMON SENSE AND GOOD JUDGMENT IN MAKING THE NECESSARY ADJUSTMENTS, TIGHTENING UP THE VARIOUS SET SCREWS, DRIVING IN THE VARIOUS KEYS, ETC. THE MAN WHO DISASSEMBLES A

MECHANISM, AND WHO CANNOT PROPERLY REASSEMBLE THAT WHICH HE HAS TORN DOWN, IS NOT A FIT MAN TO HAVE CHARGE OF A PROJECTOR. BY THIS WE DO NOT NECESSARILY MEAN THAT SOME VERY COMPETENT PROJECTIONIST MIGHT BE UNABLE TO FOLLOW THROUGH ALL THE PROCESSES WE HAVE GIVEN, AND GET THE PARTS BACK IN GOOD SHAPE, BUT THAT SORT OF MAN MAY BE DEPENDED UPON NOT TO ATTEMPT A JOB UNLESS HE KNOWS HE WILL BE ABLE TO FINISH IT.

INSTRUCTION NO. 1.—ATTACHED TO COOLING PLATE 260, Plate B, is perforated metal eye shield 567, which

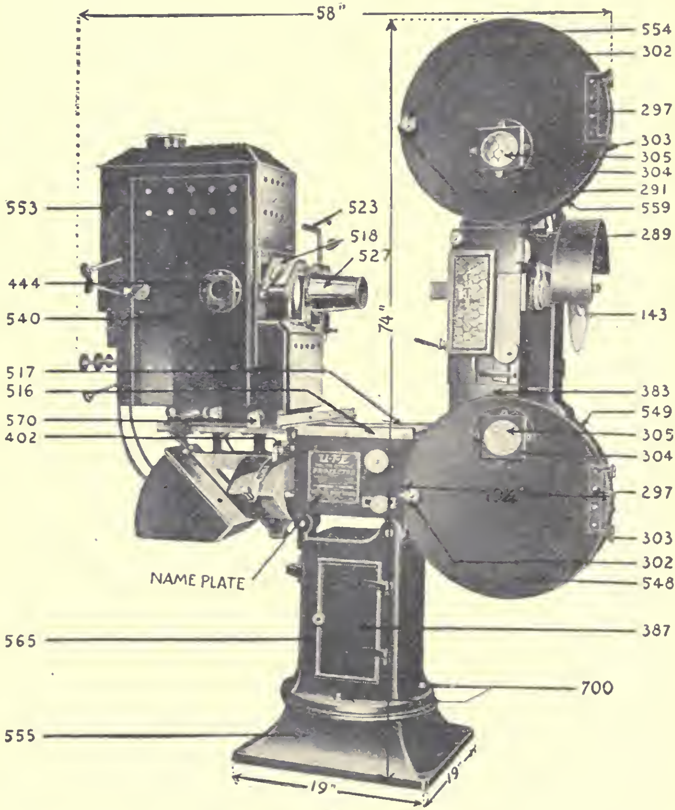


Plate A, Figure 268.

is riveted to plate 569. The assemblage of the eye shield and plate may be removed by taking out two screws, Nos. 701, Plate B.

INSTRUCTION NO. 2.—TO REMOVE COOLING PLATE 260, Plate B, first follow instructions No. 1, whereupon the cooling plate may be detached by taking out the screw in its left-hand side.

INSTRUCTION NO. 3.—BACK OF COOLING PLATE 260, Plate B, is the automatic fire shutter. To remove automatic fire shutter, first follow Instructions Nos. 1 and 2, whereupon the shutter is released by taking out screw No. 266, Plate B.

INSTRUCTION NO. 4.—ROD NO. 202, PLATE C, connects

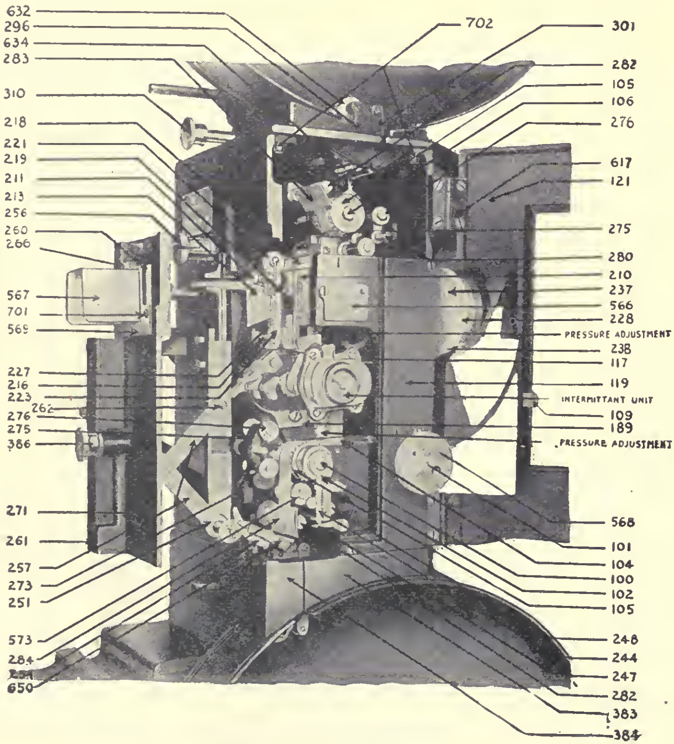


Plate B, Figure 269.

at its right hand end with a short plunger, (Stock No. 270) behind the automatic fire shutter. This plunger may be removed by first following Instructions Nos. 1, 2 and 3. In the center of the plunger you will see a steel pin. This is not a taper pin; it may be driven straight through and out through the slot in the casting, whereupon the plunger may be pulled out end-wise.

INSTRUCTION NO. 5.—BACKSHIELD 271, PLATE B, may be removed in its entirety by taking out screw 262, Plate B, and a similar one in the lower end of bar 257, Plate B.

INSTRUCTION NO. 6.—Knob No. 386, Plate B, may be removed from the center of the casting by turning it to the left. It merely serves as a handle with which to manipulate part 271.

INSTRUCTION NO. 7.—BARS 257, PLATE B, may be removed by first taking out the flat-head screws at their right hand end, next removing metal shield 261, Plate B, by taking out the two screws in its face, and then removing the two screws thus disclosed.

INSTRUCTION NO. 8.—THE RIGHT AND LEFT HAND DOORS of the projector mechanism casing may be taken off merely be removing the four screws in the hinges.

INSTRUCTION NO. 9.—THE UPPER MAGAZINE, including the cover of the mechanism casing, may be removed by taking out four screws, Nos. 702, Plate A, and 702, Plate B.

INSTRUCTION NO. 10.—BOTH THE UPPER AND LOWER SPROCKETS have four idler rollers, the stock number of which is 276. These rollers are carried on a bracket. To remove the bracket carrying the rollers, it is only necessary to take out the screw holding the bracket to its spindle, and then pull the bracket off endwise.

CAUTION.—IN REPLACING THESE BRACKETS it is absolutely essential that you get the rollers spaced an equal distance from the film. In order to do this, we would suggest that you put a double thickness of film on the sprocket and close the idler bracket down until both rollers rest upon it. This will space the rollers an equal and about the correct distance from the sprocket, whereupon tighten up the screw holding the bracket to its spindle.

INSTRUCTION NO. 11.—THE DISTANCE WHICH THE BRACKETS hold the idler rollers of the upper and lower sprocket away from the sprocket (see General Instruction No. 12), is governed by a screw located in an extension at the extreme lower end of bracket arm 273, Plate B, and a similar screw at the extreme top end of the upper bracket arm. Setting this screw further in increases the distance of the rollers from the bracket and slacking it off sets the roller closer to the sprocket.

INSTRUCTION NO. 12.—TO REMOVE THE LOWER BRACKET ARM 273, Plate B, and its shaft 272, Plate C, first follow Instruction No. 10, and then remove mechanism casing backplate 206, Plate C, by taking out three screws, two on its top and one on its lower edge, after which turn knob 239, Plate C, five or six turns to the left. Next, take out pin 201, Plate C, which releases the automatic fire shutter governor arm. Next, remove pin 192, Plate C, after which continue turning

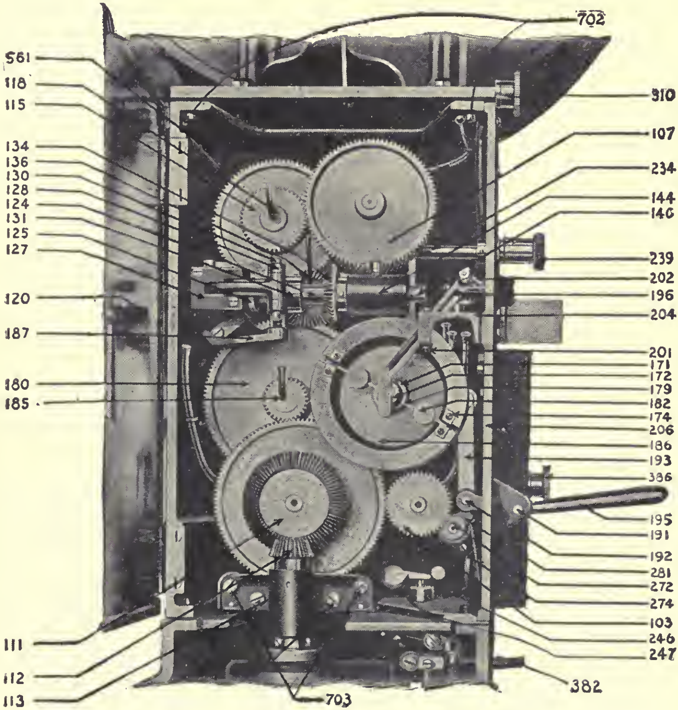


Plate C, Figure 270.

knob 239, Plate C, to the left until it releases, whereupon the backplate may be pulled away. The bracket arm 273, Plate B, and its shaft 272, Plate C, may then be taken out by slacking off the adjusting screw at its extreme lower end, which governs the distance of the idlers from the sprocket.

Next, loosen the screw which holds spring 274, Plate C, sufficiently to remove tension of the spring. Next, remove stripper plate 284, Plate B, by loosening set screw in the cast iron hub which holds it, and pulling it out to the right. You may now loosen the set screw in the face of bracket arm 273, Plate B, and drive the bracket off to the right. Having removed the bracket, a Woodruff key will be seen in the slot in the end of its shaft; take this out and the shaft can be slipped out to the left.

INSTRUCTION NO. 13.—TO REMOVE THE UPPER SPROCKET IDLER BRACKET, first follow Instruction No. 9, after which loosen the set screw and pull the idler bracket off its spindle. Next, loosen the set screw in the bracket arm, after which it can be pried off the shaft. If it is desired to remove the shaft itself, it is necessary to first follow Instructions Nos. 12, 26 and 27.

INSTRUCTION NO. 14.—TO REMOVE AUTOMATIC STOP, IDLER, PAWL AND SPRING 251, 254, and 650, Plate B, first unhook spring 650 and then loosen set screw in the lower holding bracket, and pull part 254 off to the right, which will release the whole thing. Parts 244 may be taken off merely by removing the cotter pin in the back end of shaft 248, Plate B, and pulling it out to the left.

INSTRUCTION NO. 15.—STRIPPER PLATE 284, PLATE B, may be removed by loosening the set screw in the cast iron hub which holds it, and pulling it out to the right. First, shove pawl 247 down out of the way, if necessary.

INSTRUCTION NO. 16.—TOP SPROCKET 105, PLATE B, STRIPPER PLATE 283, Plate B, and its holding bracket 282, Plate B, may be removed by loosening the two set screws at opposite diameters of the hub of the upper sprocket, and the set screw which holds bracket 282, Plate B, and pulling the assembly off to right. In order to get this sprocket out of the stripper plate, it is necessary to loosen or remove the screws which hold it to its supporting bracket 282, Plate B.

INSTRUCTION NO. 17.—APERTURE PLATE 210, PLATE B, together with gate and the parts assembled thereon, may be removed by taking out four screws in its face.

CAUTION.—IN REPLACING THE APERTURE PLATE it is necessary that it be lined properly before the screws are tightened, because the screw holes are slotted; in order to do this it is necessary to thread in a piece of film and center the aperture by making sure that the outer edge of both the film tracks are an equal distance from the edge of the film. Left aperture guide roller is mounted on a shoulder shaft, the shaft being held by a taper-head set screw. The guide roller should revolve freely, and when properly adjusted should engage left side of film, when film is threaded in mechanism. Right guide is mounted on gate, and is self adjusting.

INSTRUCTION NO. 18.—GATE 227, PLATE B, itself may be removed simply by removing the cotter pin at the lower end of the hinge, and pulling the pin out.

INSTRUCTION NO. 19.—TO REMOVE TENSION SHOES 223, Plate B, and replace them with new ones, first remove tension adjusting thumb screw 211, and a similar one just below the aperture, together with the bar and coil springs; then, with a fine pointed screw driver, take out the studs upon which the coil springs ride, which go through into the tension shoes. The old shoes may then be replaced with new ones, and the process of disassemblage reversed, being sure that the amount of tension is properly adjusted. See General Instruction No. 9.

INSTRUCTION NO. 20.—REPLACING INTERMITTENT UNIT. The entire intermittent unit, Plate B, may be taken out by removing three screws, which hold it to the mechanism casing. When these three screws are removed, the whole unit may be lifted away and replaced with another unit, while any repairs necessary are made on the old one. After the intermittent unit is removed, looking at the end of the driving shaft from which it was disengaged, you will see a slot in its center, at one end of which is a small hole.

Examining the end of the shaft of the intermittent itself, you will see a metal tongue, in the end of which is a pin. This tongue fits into a groove in the end of the driving shaft, and can only be so fitted when the pin enters the hole at the end of the slot. This is to prevent there being any disturbance of the relation of the intermittent shutter and the intermittent movement, when the latter is removed and replaced, or removed and replaced by another movement. In other words, it is impossible to put on a new intermittent movement, or to replace the old one in any way which will disturb the timing of the shutter and intermittent movement.

CAUTION.—In replacing the intermittent, always have the framing lever at the extreme top of its travel—up as far as it will go. In replacing the intermittent, or putting in a new one, always set the tongue in approximately the same position as the groove, then place the intermittent in position, and rock it gently until the tongue seats in the groove, so that the face of the casting and the face of the intermittent unit are snugly together, after which the screws may be replaced and tightened up.

INSTRUCTION NO. 21.—FRAMING CARRIAGE ADJUSTMENT. Should the framing carriage work too hard, or too loose, it may be adjusted as follows: On Plate B you will find two arrows marked "Pressure Adjustment," pointing to hexagon nuts. Examining these, you will notice the stud they are on has a screwdriver slot in its end. The nuts themselves are lock nuts only. For the adjustment of the framing carriage, loosen the lock nut, which has a right-hand thread, and with the screwdriver turn the bolt to the right to make the framing carriage work harder, and to the left to make it work easier. Then tighten the lock nuts.

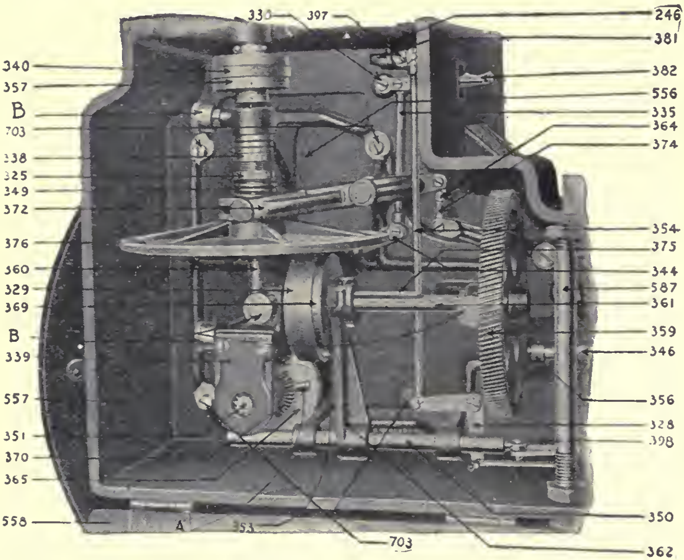


Plate D, Figure 271.

INSTRUCTION NO. 22. — REMOVING LOWER SPROCKET.—On the hub of knurled knob 568, on crank-shaft 101, Plate B, is a set screw. Loosen this set screw and pull the knob off.

CAUTION.—This knob is put on with a Woodruff key. Don't lose it.

Next, remove the taper pin in auto stop cam 102, Plate B. Opposite the small end of this pin on the face of the part, you will find a center punch mark. Next, remove part 247, Plate B, by taking off the nut and sliding the part off its spindle, which releases part 247, Plate C, and its shaft, which may then be pulled out to the left. Next remove the mechanism side-plate 119, Plate B, by taking out two screws at its top end, the screw which holds part 566, Plate B, one screw to the right of the oil hole of shaft 101, Plate B, and two screws at the lower end.

It is not necessary to remove the four small round head screws in the center of the plate. Next, remove lower stripper plate 284, Plate B, as per instruction No. 10. Next, loosen the set screws in the lower sprocket (two of them),

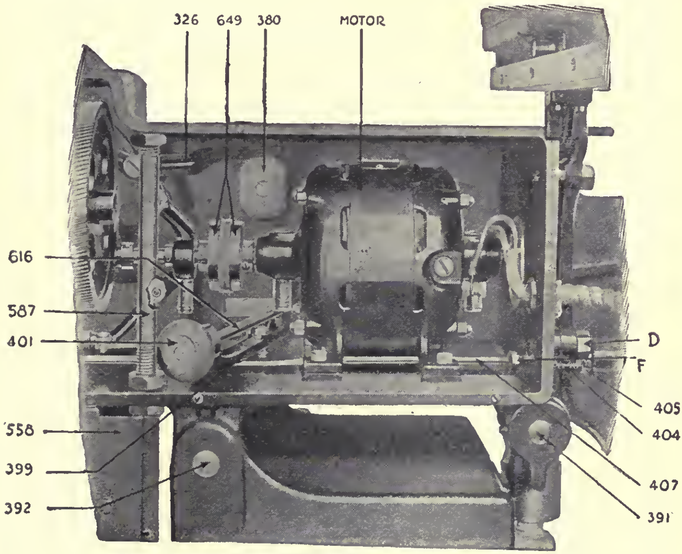


Plate E, Figure 272.

and slide the sprocket off the shaft to the right. Its shaft 100, Plate B, and its driving gear 103, Plate C, may then be pulled out to the left.

INSTRUCTION NO. 23.—MAIN LENS CARRYING TUBE

237.—Plate B may be taken out as follows: Remove the screw which holds part 566, Plate B; also the flathead screw just above and a little to the right of it. Then, looking through the opening under part 566, you will see, on the opposite side, two rather large machine screws in the upper left-hand corner. Remove them, and the entire casting, aperture plate, gate, and top plate may be lifted away. Then, first having removed lens adapter 228, Plate B, by unscrewing it, and taking out two screws at the top of the lens tube carrier, which same are immediately below the shaft carrying the top sprocket main idler bracket, the whole lens tube can be pulled out to the rear.

INSTRUCTION NO. 24.—TO REMOVE REVOLVING SHUTTER GUARD 289, Plate A, together with the revolving shutter, it is better to first take off the dissolving shutter and bar (not shown in photographs) which is attached to the shutter guard. This may be done by removing the screw at its right-hand end and pulling the bar out to the right. Next, loosen the big set screw in the hub of the revolving shutter, which holds it to the shaft, and pull the revolving shutter off. You have then only to remove the two screws which hold the guard to the mechanism, which releases the guard.

INSTRUCTION NO. 25.—REMOVING REVOLVING SHUTTER. (See Instruction No. 24.)

INSTRUCTION NO. 26.—GEAR 107, PLATE C, is held by a set screw and a Woodruff key. The gear may be removed by slacking off the set screw, and then screwing out the oil cup on top of part 144, Plate C, and pulling the gear off.

INSTRUCTION NO. 27.—DOUBLE GEAR 115, PLATE C, may be removed by first following instruction No. 26, then slacking off on the set screw which will be found about 1¼ inches above and ½ inch to the right of the upper right-hand screw holding part No. 238, Plate B. Back this screw off about two turns, whereupon the stud which holds the gear may be pulled out to the left, or may be shoved out by placing a bar of wood against its inside end and tapping gently. In replacing the stud, drive it in gently if it fits snugly, and be sure it is not tight enough to bind the gear, also that it is in far enough so that there is no end play in the gear, after which tighten up the holding screw on front of the mechanism casing.

INSTRUCTION NO. 28.—TO REMOVE MAIN DRIVE BRACKET 113, and pinion 112, Plate C, take out four screws, Nos. 703, Plate C. The bracket and the top end of part 357, Plate D, may then be lifted away.

INSTRUCTION NO. 29.—TO REMOVE FLYWHEEL 186, PLATE C, first remove pin 201, Plate C, and swing automatic governor lever arm 196, Plate C, up out of the way. On the flywheel hub is a flange collar, 172, Plate C, back of which is a coil spring. Press this spring back and in the hub of collar 172 you will see a set screw, the removal of which releases both collar and spring. Then in collar 171, Plate C, you will find another set screw, which should be removed. This will release the collar and the plunger pin in the center of the flywheel shaft. The flywheel is held to the shaft by

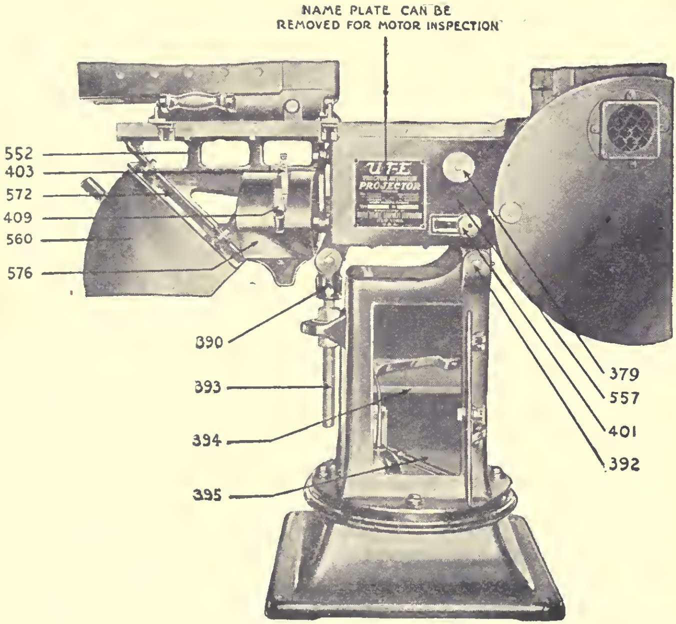


Plate F, Figure 273.

means of a taper pin through the inside center hub. On the face of the flywheel close to the small end of the pin you will see a small center punch mark. In the rim of the wheel are two holes through which a drift-pin can be inserted in order to drive out the pin, or tighten it up. After driving out this pin, which will require a long tempered steel punch with a flat end, you can pull the flywheel off.

CAUTION.—In performing these various operations, be very careful that you remember just how the various parts go back. There is no difficulty or mystery about it, nor are there any fine adjustments to be made, or any adjustments at all for that matter. It is, however, essential that you get the various parts back the way they belong, and properly anchored in place.

INSTRUCTION NO. 30.—TO REMOVE GEAR 111, PLATE C, which carries two gear faces, you must first follow instructions Nos. 28 and 29. Then loosen the set screw in the hub of part 568, Plate B, and pull 568 off, removing the Woodruff key which you will find in a slot in the end of the shaft. Gear 111, Plate C, may then be pulled out.

INSTRUCTION NO. 31.—TO REMOVE GEAR 180, PLATE C, first follow instructions Nos. 28, 29 and 30. Next, turn revolving shutter until you can see a set screw in front plate of the mechanism, just below the right-hand lower corner of the casting, part No. 238, Plate B, carrying the lens tube. This set screw holds the stud upon which gear 180, Plate C, runs. Back this screw off two turns, and you can pull the stud out, releasing the gear. If it be a little tight, place the end of a drift pin on wooden bar against the end of the shaft on the side opposite from the gear and tap lightly.

INSTRUCTION NO. 32.—TO REMOVE FRAMING CARRIAGE, first follow instructions Nos. 20, 28, 29, 30 and 31 and remove pin 192, Plate C. Next, take out the three screws holding part 189, Plate B, which will release same together with the entire framing carriage casting. The framing carriage carries two phosphor-bronze bushings in which the flywheel shaft runs. We would not advise the projectionist to attempt the replacing of these bushings. Should they become worn, it would be better to order entire framing carriage casting from the the factory. Its stock number is 190.

INSTRUCTION NO. 33.—SHUTTER BRACKET UNIT. To remove revolving shutter shaft, first remove the dissolving shutter. This may be done by taking out the screw at its right-hand end, and sliding the shutter out at its left. Next, loosen the set screw which is the hub of the revolving shutter, and pull the shutter off the shaft. Then take out the two screws in the face of part 127, Plate C, which releases part 127, and yoke 128, Plate C. Next, in one side of part 131, you will see a straight pin, which may be driven out in either direction. This releases the stud which you will see in the face of part 131. It will probably come out with a little coaxing, if not, then make a wire hook and, reaching in behind, pull the stud out. Next, drive out the taper pin in collar 125, Plate C, the small end of which will be marked with a center punch mark. You can then pull the shutter shaft, 124, out.

INSTRUCTION NO. 34.—GEAR 134, PLATE C, AND ITS SHAFT, may be removed by first following instruction No. 33, and then driving out the taper pin in the hub of gear 134, Plate C, after which the shaft may be pulled out to the right. Back of, and meshing with gear 134, Plate C, is a Bakelite gear 136, Plate C, which also meshes with, and takes its power from the large gear surface of gear 180, Plate C. It is only necessary to follow instruction No. 33, drive out the pin in collar 125, Plate C, and pull the shutter shaft ahead (towards the screen) as far as it will go. Then, just to the right of and below the top right-hand screw holding the lens casting, Part No. 238, Plate B, to the front frame, is the set screw which holds the back end of the stud upon which gear 136 rides. Loosen this set screw and the stud may be pulled out.

INSTRUCTION NO. 35.—TO REMOVE ENTIRE REVOLVING SHUTTER BRACKET, it is necessary to first follow Instruction Nos. 25, 26, 27, 28, 29, 30, 31, 32, 33 and 34, and then remove the three screws holding the shutter bracket to the frame. This releases the entire unit, which may then be pulled out.

INSTRUCTION NO. 36.—SPEED CONTROLLER UNIT. The speed controller unit, shown in Plate D, may be removed in its entirety by taking out six screws, all numbered 703, four of which show in Plate D, the other two being behind rod 587, Plate D, disconnecting coupling 649, Plate E, and take out pin No. 390, Plate D.

NOTE.—The position of part 328 has been reversed, the action and connection is precisely the same, but the part sets just the opposite from the position shown in the photograph.

Next, take out two screws, 330-397, Plate D, and pull out the pin at the bottom end of part 328, Plate D. This releases the whole speed controller unit, which may be lifted out of the machine.

INSTRUCTION NO. 37.—THE DRIVING MOTOR, shown in Plate E, may be removed by taking out the four hexagon-head nuts, which hold it to the frame. Two of them are reached by removing the name plate, Plate A, disconnecting coupling 649, Plate E, and the wires.

INSTRUCTION NO. 38.—BRUSH ADJUSTMENT. If any motor is D. C., the brushes on right side may be reached by taking off name plate, Plate A. **In taking out and replacing brushes be very careful that you do not disturb their adjustment.** If the motor is D. C., and it at any time fails to develop power, it would be well to first examine the brushes and see that they are making proper electrical contact with the commutator.

INSTRUCTION NO. 39.—ADJUSTING HEIGHT OF MOTOR. Looking at the under side of the compartment in which the motor is contained, you will see four adjustment screws. These are for the purpose of adjusting the height of the motor. They will not be called into use unless a new motor be installed, in which case if the shaft is too high or too low, it is only necessary to adjust the height by means of these studs, but

CAUTION.—In doing this, be very careful that you turn each one of them exactly the same amount; otherwise you will have your motor sitting on an uneven base.

INSTRUCTION NO. 40.—ADJUSTING AUTOMATIC STOP. In case the automatic safety stop does not open the driving motor switch when the film breaks, then its adjustment should be examined. First make sure that everything is working freely. Try pulling rod 407, Plate E, back and forth to make sure it does not bind, then set collar 405 so that the plunger extends far enough out from the right-hand end of casting D, Plate E, to engage the lip on the arm which throws the switch, **but not to exceed 1/16 of an inch.** Adjustment F, Plate E, should be so made that pawl 247, Plate B, just clears the lower end of pin 244, Plate B. With these adjustments made as directed, the automatic stop should work perfectly. Remember there may be some side shake to the switch throwing lever, therefore have the pin engage the lip on the lever by 1/16 of an inch **when the lever is as far as it will go to the right.**

INSTRUCTION NO. 41.—FRICTION DISC WHEEL 329, Plate D, has a face approximately ⅞ of an inch wide. It is composed of leather, clamped between two cast iron discs. It should wear for a long time. To replace, first order new leather drive pulley washers from the factory. To remove, first follow Instruction No. 36, then drive out the taper pin in the collar to the left of the bearing carrying gear 359,

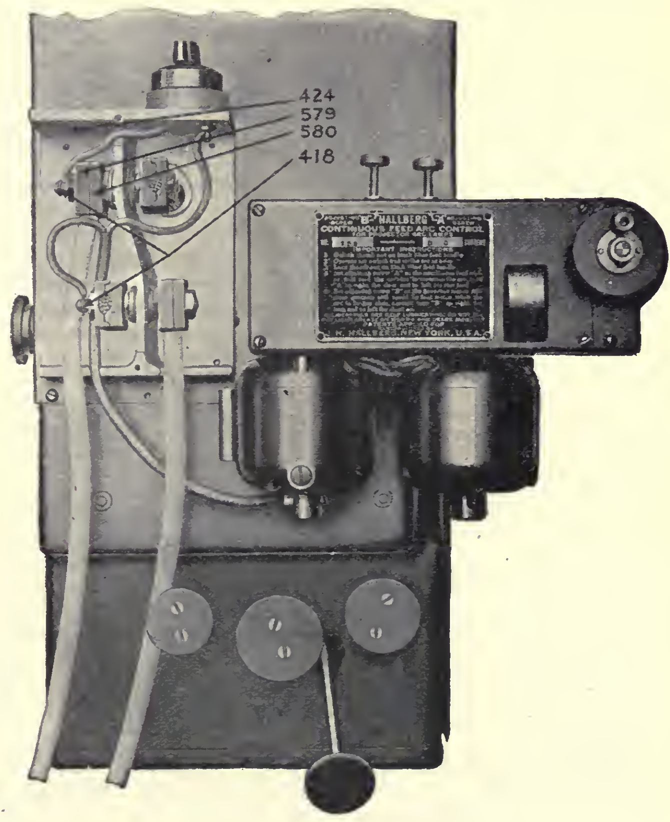


Plate G, Figure 274.

Plate D, after which the shaft may be pulled out to the right sufficiently to release the friction disc wheel.

NOTE. It is possible, by driving out the pin in the collar to the left of the bearing carrying gear wheel 359, Plate D, and the taper pin in the hub of gear 359, Plate D, removing the screw in the face of key 375 and pulling the key out, to slip the shaft out to the right, without removing the unit in its entirety from the machine. If the shaft sticks in the hub of gear 359, however, we would not advise trying to drive it out, unless it can be started by tapping on the left hand end of the shaft very gently, using a drift pin or a wooden bar for the purpose.

INSTRUCTION NO. 42.—Should any fault develop in friction disc 376, Plate D, necessitating its removal, it may be done as follows: First follow Instruction No. 36. Next remove bevel pinion 353 at the lower end of shaft 360, by releasing the set screw in the hub of bevel gear 353 at the lower end of shaft 360, and prying the gear off, after which remove the Woodruff key, which holds gear, from the slot in the shaft. Next, drive out the taper pin from part 338, Plate D, remembering that the small end of all taper pins is marked with a center punch mark. Next, take off part 357 by releasing the set screw in its hub, prying the part away, and taking care of the Woodruff key which holds the part to the shaft. The shaft may then be gently driven or shoved downward, which will disclose a short key which normally is under the lower end of the hub on friction disc 376. Remove this key, after which the shaft can be pulled upward, releasing the whole assemblage.

CAUTION: Before attempting a job of this kind, or in fact in any considerable job of disassembling, examine the mechanism very, very carefully and be sure you understand just how everything goes. In reassembling you will be greatly aided by the photographs, but you should not depend on them too much, partly for the reason that slight structural changes may be made from time to time, and for the further reason that you should not try to make extensive repairs and adjustments until you first thoroughly understand the mechanism.

INSTRUCTION NO. 43.—TAKE-UP TENSION ADJUSTMENT. The take-up tension adjustment is of the friction disc type, Plate D, composed of two steel discs between which is clamped a fibre disc. One of these discs is attached directly to the driving mechanism, and has a constant positive speed of rotation. The other side of the disc is pinned to the shaft that carries the take-up reel, and is rotated wholly and entirely through friction with the fibre disc clamped between the two. The amount of pull that will be exerted on the take-up depends upon the pressure with which the two discs are held together, which is regulated by means of a coil spring, the tension of which may be adjusted by turning a threaded collar. You can rotate this collar by reaching in behind the disc, between the disc and the back wall of the compartment. The disc is shown as 365, Plate D. The adjusting collar and spring is behind it.

The whole take-up assemblage, including the shaft upon which the lower reel rides, may be removed by releasing the set screw in the collar on the shaft in the lower magazine, and pulling both locking key and the collar off the shaft. Next, take out the two screws which hold part 339, Plate D, (then follow Instruction No. 28 if complete speed controller unit is not removed) then release set screw in bevel gear No. 353 at lower end of shaft 360, prying the gear off and removing the Woodruff key, after which shaft 360 can be pushed up slightly, whereupon the whole thing, including the friction disc, bevel gear and the take-up shaft may be pulled out.

INSTRUCTION NO. 44.—Plate G illustrates the method of connecting the wires from the projector switch to the junction box, and from it to the lamp; also the controlling switch of the Hallberg Continuous-Feed Arc Control, and the necessary connections.

INSTRUCTION NO. 45.—CARE AND LUBRICATION OF THE LAMP. See Page No. 371.

INSTRUCTION NO. 46.—LUBRICATION. In the compartment shown by Plate C, (left-hand side of the mechanism) are eight oil tubes, two oil cups on the top of the revolving shutter shaft bracket, and an oil hole in the side of part 113, Plate C. For directions concerning lubrication see General Instruction No. 1. In the compartment illustrated in Plate D, oil cup A revolves with the shaft. It should have about two drops of oil a day. Ball-bearings on both ends of shaft 351, Plate D, should be kept lubricated with automobile or motor generator cup grease.

Cups B B B B, Plate D, (four of them) must be kept filled with automobile cup grease, and should be given about half a turn every second day, provided it is an all-day house; every four days, if it is an evening house only. The motor oil cups and the other two under-hanging oil cups on the same shaft are all wick oilers. They may be re-filled without removal, simply by inserting the snout of a small squirt can in the hole in their side and pumping oil in. This need not be done more than once a week.

In Arm 362, Plate D, at the right of friction disc 329, Plate D, is an oil tube, in the top of which is a small screw. **Be careful and don't put more than one drop of oil at a time in this tube.** If you get too much oil in, look out for trouble with your speed controller, because the oil will run down, get on the face of your friction disc and cause slippage. The only two other points to oil are an oil-hole back of part 568, Plate B, and in the hub on the bearing at the right-hand end of shaft 100, Plate B.

With regard to the intermittent, the oil level ought to be just about at the lower edge of the glass and **no higher.**

CAUTION: Don't fill the oil well. Keep the level down to the lower edge of the glass. We would recommend that the intermittent unit be taken out (See Instruction No. 20), the oil cup opened and the oil completely drained out. We would also recommend that a little kerosene be squirted in and afterwards it ought to be very well cleaned out, at fixed intervals, so as to clean the whole movement and the glass, after which fresh oil can be put in up to the proper level. The manufacturers recommend the use of a special intermittent lubricant which may be obtained from them. It is a little thinner than vaseline; this lubricant is recommended by them because it has no tendency to leak out through the bearings.

INSTRUCTION NO. 47.—By turning knob 397, Plate F, to the right or left, the friction disc is released and the projector stopped without disturbing the motor, and by pressing the lever 382, Plate D, the speed of the projector may be checked for short titles, etc., this lever operating against the brake which bears on the outer edge of under side of friction disc 376, Plate D.

KNOWLEDGE IS POWER.

Motiograph De Luxe Model

THE Motiograph, De Luxe Model, has a lamphouse of ample dimensions. At the time this work goes to press there is a lamphouse and lamp of heavier construction in process of making. The present lamphouse (1921) is illustrated in Fig. 274 A. The metal is of heavy Russian iron. Doors are double walled, with a ⅝ inch ventilated air space between. Top has a vent for attaching to a pipe leading to open air or projection room vent flue. Dimensions are, front to back 16.5 inches, Fig. 274 A, with a recess under the condenser, which allows of bringing the arc very close to condenser. In effect it adds 2⅞ inches to length of lamphouse. Floor to top of gable is 28 inches.

The condenser casing is so arranged that the projectionist has easy access for replacement or cleaning. The condenser lenses are held in metal rings which are calculated to equalize expansion and contraction of thin edge and thick center of lenses, which to an extent controls breakage. There is means provided for altering distance between collector and converging condenser lenses at will. The dowser is an "outside" one. Maximum possible distance obtainable between center of condenser and aperture 21 inches; minimum distance 13 inches. Minimum distance crater may be placed from face of collector lens when lamp is at ordinary working angle, 2⅝ inches.

The arc lamp wire terminal clamps are shown in Fig. 274 B, details of the clamp being clearly shown in the picture. The carbon clamps are made of a fine grade of gray iron. They have a plunger of steel. The gripping surface is sufficient to insure good contact between clamp and carbon.

USEFUL DATA.—The following tabulation shows necessary distance of center of Motiograph De Luxe model pedestal from wall when projector is set at different angles, allowing a five inch clearance between upper magazine and wall at all angles. In this you will of course understand that as the projector is tilted at an angle the upper magazine is moved forward toward the wall, therefore the base must be moved back correspondingly. These figures will be of use in determining the position of the wire outlets and front to back length of the room when same are being planned.

Angle	Distance in Inches	Angle	Distance in Inches
0°	28 4/16	11°	36 3/16
1°	29¼	12°	37 1/16
2°	30	13°	37 9/14
3°	30¾	14°	38 3/16
4°	31⅜	15°	38¾
5°	32 3/16	16°	39½
6°	33	17°	39⅞
7°	33 9/16	18°	40¾
8°	34 3/16	19°	41⅜
9°	34⅞	20°	42 1/16
10°	35 9/16		

Plate 11.

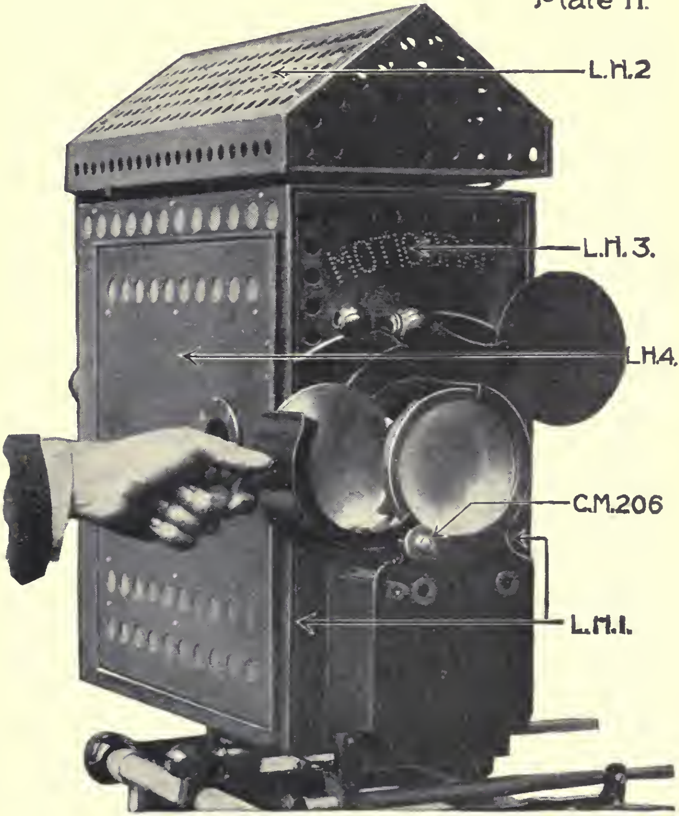


Figure 274 A

INSTRUCTIONS FOR MOTIOGRAPH DE LUXE

NOTE.—The instructions may seem complicated, but really are simple. If followed intelligently and accurately the projectionist should experience no difficulty in their application. "P.1," "P.3," etc., means Plate 1, Plate 3, etc. Reference to general instructions means the general instructions which apply alike to all projectors. They begin on page 592.

INSTRUCTION NO. 1.—TO REMOVE THE FILM GATE, CS-4.P.2, Raise gate latch CS-33,P.2, and pull lower part of gate outward until it stops. Press the two hinge knobs CS-20,

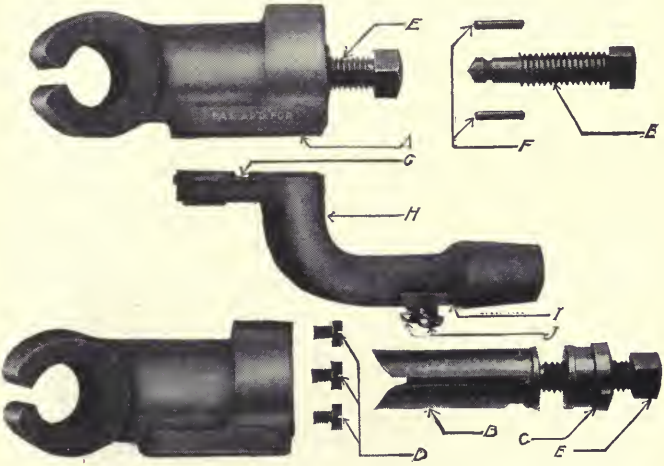


Figure 274 B

P.2, towards each other until the hinge pins are released. Remove top part of gate from between the hinge joints. Unhook film gate stop CS-158,P.5, from gate and disengage gate slide link SF-84,P.5, whereupon gate slide CS-97,P.5, may be removed by sliding it upward on the film gate to allow screw heads CS-116,P.5, to pass through openings in ends of the slots on gate slide.

INSTRUCTION NO. 2.—TO REMOVE AUTOMATIC FIRE SHUTTER CS-246,P.5, first remove the two screws CS-88, P.5, and then circular plate CS-86,P.5. Rack lever CS-72,P.5, may be removed by removing screw CS-79 from boss CS-75, P.5, at center of lever.

TO RAISE AUTOMATIC FIRE SHUTTER BY HAND

press pin CS-77,P.2, to the left. This pin projects from upper left hand corner of gate.

INSTRUCTION NO. 3.—TO REMOVE FILM TENSION SHOES CS-105 and CS-107,P.5, from film gate slide CS-97, P.5, take out screws (4 of them) CS-109,P.6. The tension springs which act on these shoes lie between the shoes and the gate slide, with their ends against the gate slide. Screws CS-109 pass through slots in the ends of the springs.

NOTE.—WHERE MUCH FIRST RUN, WAXED FILM IS PROJECTED, washers may be had for use under screw heads CS-109,P.6, of the two upper tension shoes. These washers release the tension of the springs, so that the tension shoes are guides only.

INSTRUCTION NO. 4.—TO REMOVE CRADLE CS-249, P.5, which holds film to intermittent sprocket, take out screw holding spring (not shown) which governs the cradle. Re-

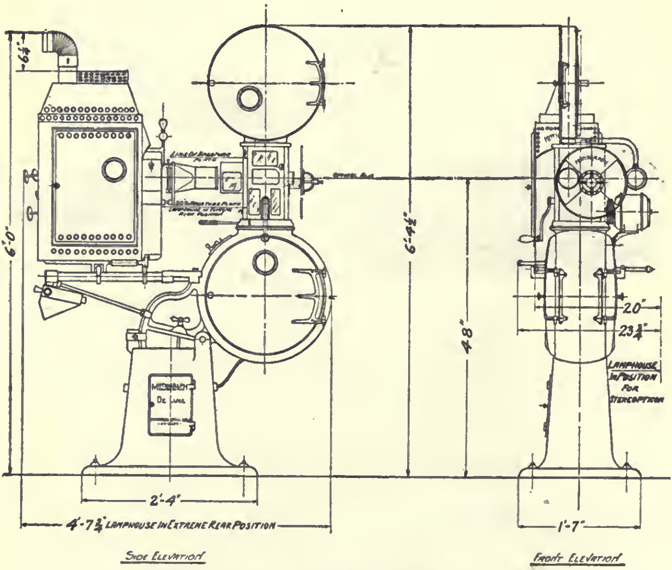


Plate I, Figure 275.

Dimensions of Motiograph De Luxe Model. These dimensions may be depended upon, taken in connection with the tabulation under "Useful Data," for use in locating wire outlets, etc.

moval of spring releases cradle, or, as the manufacturer calls it "intermittent sprocket film tension."

NOTE.—Under the spring is a collar, stock number of which is CS-188, and on top of the spring is a washer, No. CS-189. It is important that collar and washer be in place.

INSTRUCTION NO. 5.—TO REMOVE FILM GUIDE ROLLERS CS-101 and CS-102,P.5, or film guide roller CS-93,

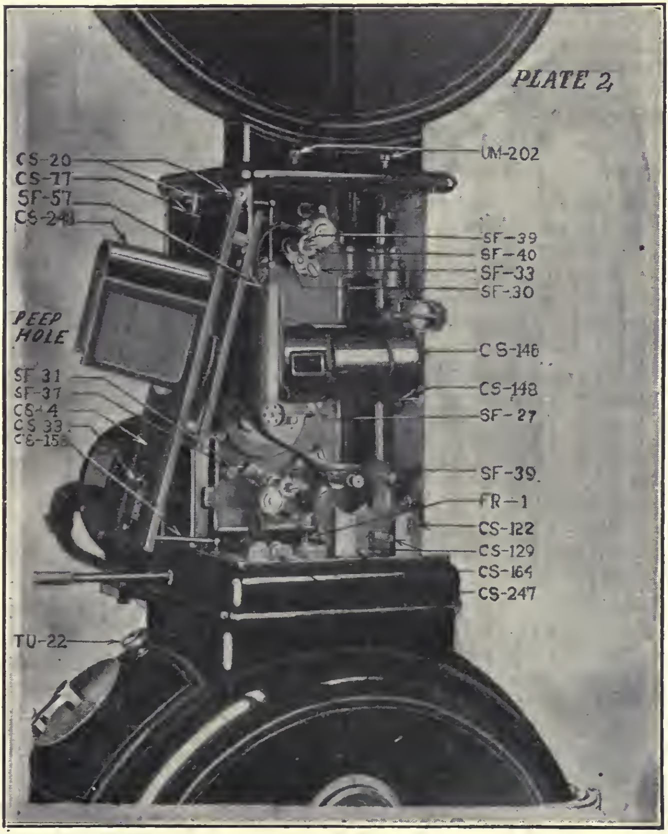


Plate 2, Figure 276.

P.5, the first two being at top of film gate slide and the last named at bottom of intermittent sprocket cradle, it is only necessary to take out the screw shaft which holds them.

INSTRUCTION NO. 6.—TO REMOVE ENTIRE INTERMITTENT MOVEMENT GB-75,P.3, AS A UNIT, including oil casing, flywheel and intermittent sprocket, open gate in order that intermittent sprocket cradle, or tension shoe, be released from sprocket. Next loosen screw CS-127,P.6, a few turns. Remove screw SF-21, from back end of crank shaft. Push crank shaft out of main gear toward operating side of mechanism. Remove main gear, loosen clamp screws SF-10, P.6, and slide washers they hold (SF-12) away from flange of geneva intermittent box, or oil casing. Grasp flywheel with left hand and pull it straight out until the geneva box is partly removed from frame, then turn the box about one quarter turn to the right and pull it out.

IN REPLACING GENEVA INTERMITTENT BOX, see that the "notch" on the rim of the casting is upward, and that it engages with stud SF-II, P. 6, the stud being at top of opening in frame into which intermittent box fits. The box of necessity fits closely into the frame opening. Do not force it in, but work it gently into place. It will go when you have it right. If you try to force it you may do great damage.

INSTRUCTION NO. 7.—TO OPEN THE GENEVA INTERMITTENT BOX, or oil well, GB-75, P. 3, first follow Instruction No. 6 and then remove the four screws GB-17, P. 8. The cover is not threaded to the box, but is prevented from turning and is held in proper relationship to the box by dowel pin GB-5, P. 8. The cover is machined to an oil-tight fit, hence must be handled very carefully. If it be struck or scratched by anything, then when it is replaced the joint will in all human probability not be oil tight.

CAUTION.—In replacing the oil well cover be very careful that both surfaces are **perfectly clean,** but wipe them with a clean soft cloth only from which all lint has been removed. Also that pin engages with cover made to receive it.

INSTRUCTION NO. 8.—TO REMOVE INTERMITTENT SPROCKET, SHAFT AND STAR, first follow Instruction No. 6 and then loosen screws GB-21, P. 3, which hold stripper plate stud GB-19, P. 3, to the cover and turn stripper plate GB-18, P. 3, away from sprocket. The intermittent sprocket is held to its shaft by two taper pins. Before attempting to remove these pins study general Instruction No. 5 carefully, and either use V block shown in Fig. 225 or its equivalent. Removal of the pins will release both sprocket, star and shaft.

NOTE.—We do not advise the projectionist to attempt any job which involves removal and replacement of intermittent sprocket. We strongly advise the purchase of a spare intermittent unit, and that when such a repair becomes necessary

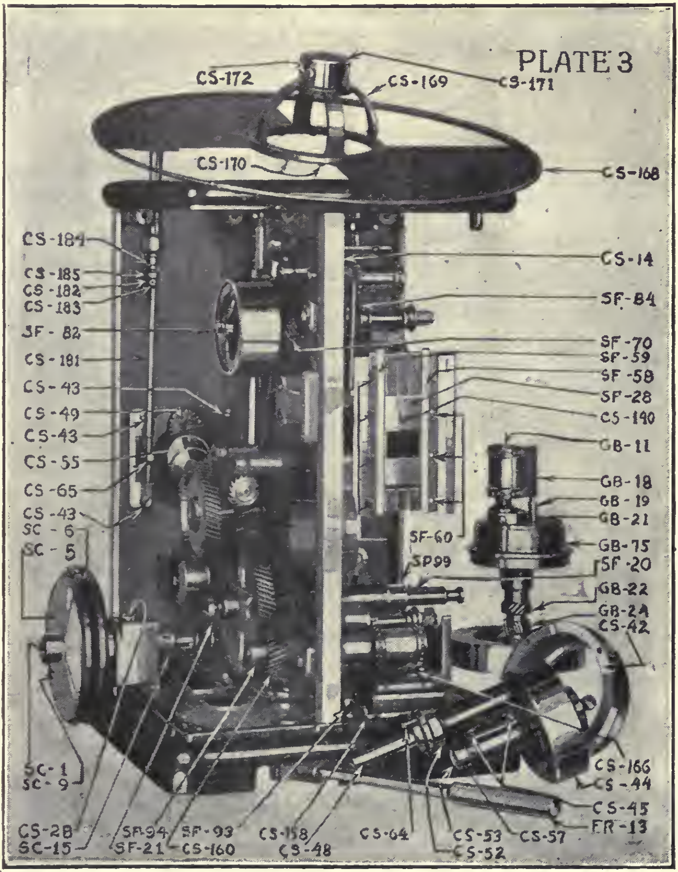


Plate 3, Figure 277.

that the spare be inserted and the unit in need of attention be sent to the factory, which is the only place such a job can be done right. We give instructions, yes, but only to help those who are by circumstances forced to attempt the removal and replacement of an intermittent sprocket.

INSTRUCTION NO. 9.—TO REMOVE THE CAM ELEMENT OF INTERMITTENT MOVEMENT, GB-77, P. 8, first follow Instructions Nos. 6 and 7. Next remove screw GB-26, P. 4, which is screw in end of flywheel shaft, and key washer GB-25, P. 4, and pull flywheel and pinions GB-22 and GB-24, P. 8, off shaft. You may then pull cam and shaft out through oil box.

CAUTION.—Again we advise against attempting repairs on intermittent unit. Do it if you are compelled by circumstances to, but the parts must, in the very nature of things, fit closely. The measurements are in thousandths, or even ten-thousandths of an inch. The projectionist is seldom or never equipped to work to such accuracy. Better get a spare intermittent unit. Costs something, yes, but is worth it.

INSTRUCTION NO. 10.—ADJUSTMENT OF INTERMITTENT TO ELIMINATE LOST MOTION IN SPROCKET. First turn flywheel in direction it normally runs until intermittent sprocket just stops, then give it about an eighth of a turn more. This insures the intermittent being "on the lock," as is necessary for this adjustment. Next loosen screw GB-8, P. 6 and 8, which will be found in hub of oil casing cover carrying intermittent sprocket shaft and bushing. Release this screw by only about one turn. Do not remove it. Next, using small wrench GB-27 (not shown), or some other suitable wrench, turn hexagon nut of bushing (between sprocket and hub) in whichever direction accomplishes the purpose, at the same time "rocking" intermittent sprocket with finger. When the movement is tight enough that you can barely feel a movement of the sprocket it is right. Tighten up screw GB-8 and the job is done.

CAUTION.—Test for lost motion in sprocket should be made immediately after a picture has been projected, because then the parts are expanded by heat of operation to their operating size. The adjustment should be made when projector is cold, at which time if there be just a slight movement of sprocket, when parts are heated by operation they will be quite sufficiently tight. Remember that if you get them too tight undue friction will be set up, which will further increase expansion and friction. Too much lost motion of the intermittent sprocket is bad—too tight an adjustment is still worse.

INSTRUCTION NO. 11.—TO REMOVE UPPER AND LOWER SPROCKETS SF-88, P. 5, it is only necessary to loosen screw and turn stripper plate back out of the way. Then remove screw from sprocket hub and pull sprocket off shaft.

INSTRUCTION NO. 12.—TO REMOVE UPPER OR LOWER SPROCKET IDLERS, remove screw SF-40, P. 2, which is in end of spindle upon which roller turns.

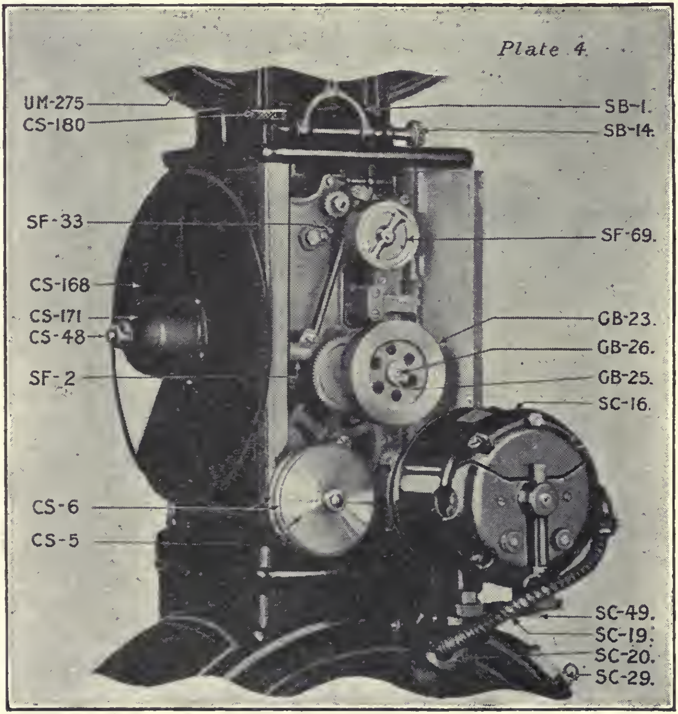


Plate 4, Figure 278.

INSTRUCTION NO. 13.—TO REMOVE UPPER OR LOWER SPROCKET IDLER BRACKETS, SF-30 and SF-31, P. 2, it is only necessary to take out SF-33, P. 4 and 6, which are on opposite side of center wall of frame from the sprockets.

INSTRUCTION NO. 14. — ADJUSTING SPROCKET IDLERS. See general Instruction No. 12, and study same.

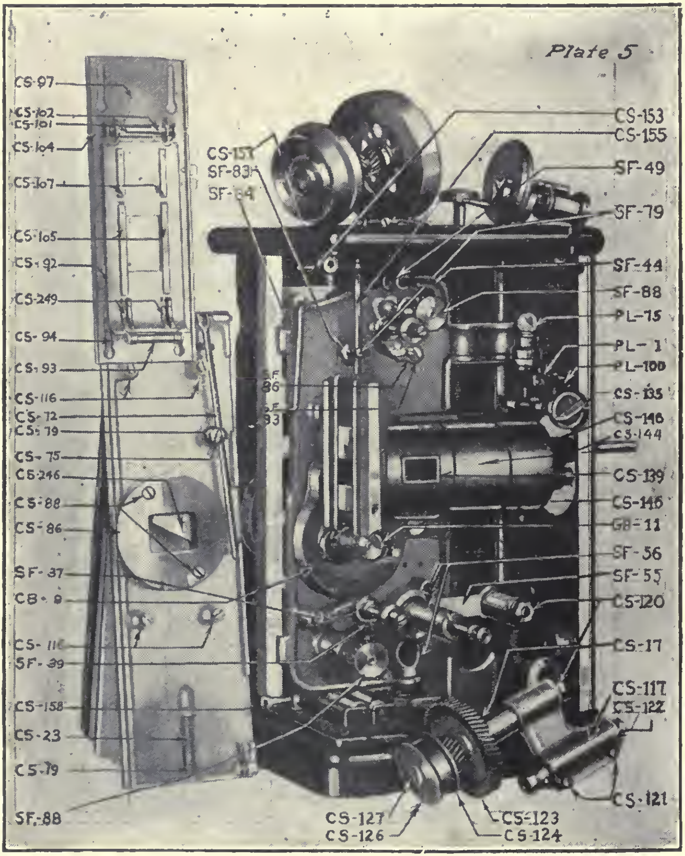


Plate 5, Figure 279.

To adjust upper or lower sprocket idlers loosen screw SF-33, P. 5, slightly and, using screwdriver, turn eccentric SF-86, P. 5, until proper adjustment according to general Instruction No. 12 is obtained, whereupon retighten holding screw.

INSTRUCTION NO. 15.—TO REMOVE FILM TRACKS, SF-58 and SF-59, P. 3, first follow Instruction No. 1 and then

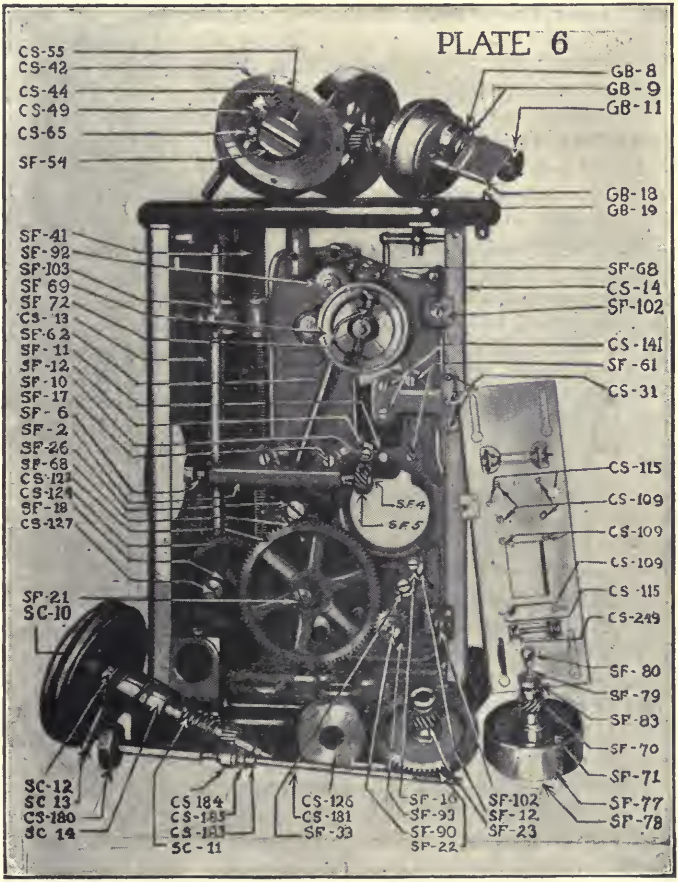


Plate 6, Figure 280.

remove the eight screws SF-60, P. 3, in face of tracks. This releases tracks.

INSTRUCTION NO. 16.—TO REMOVE APERTURE PLATE. Follow Instruction No. 15. Removal of film tracks also releases aperture plate, which is located by pin CS-140, P. 3.

INSTRUCTION NO. 17.—TO REMOVE PROJECTION LENS BARREL, consisting of CS-139, CS-144 and CS-146, P. 5, remove two screws, CS-141, P. 6. Remove track support SF-57, P. 2, by taking out two screws, SF-61, P. 6, which will release all parts of lens tube, including focusing screw.

INSTRUCTION NO. 18.—TO FOCUS PICTURE ON SCREEN use focusing screw winged thumb nut CS-135, P. 5, which protrudes from right hand side of mechanism casing near its front edge.

INSTRUCTION NO. 19.—PLACING LENS IN BARREL. At bottom of front end of lens barrel is a clamp screw, CS-148, P. 2, by means of which lens tubes are clamped in lens barrel To insert lens tube loosen this screw and back it off. A sleeve, collar or adapter will be supplied by manufacturer, upon application, to reduce diameter of lens barrel to fit any desired diameter lens tube. Get collar to fit, insert collar and tube. Strike arc, raise fire shutter and project white light (without film) to screen. Move focusing screw CS-135, P. 5, until lens tube is in center of its travel. Shove lens tube in and out until you get edges of light sharply focused on screen, whereupon tighten clamp screw CS-148, P. 5, tight, and the job is done. The picture may then be sharpened on screen by focusing screw when projection is started.

INSTRUCTION NO. 20.—TO REMOVE GRIPPING DISC UNIT SC-100, shown as SC-5, SC-6, P. 3 and 4, remove screw CS-28, P. 3, which engages cam slot in the collar. You may then withdraw the unit.

INSTRUCTION NO. 21.—TO DISASSEMBLE GRIPPING DISC UNIT SC-100, shown as SC-5 and SC-6, P. 3 and 4, follow Instruction No. 20, then drive out taper pin SC-9, P. 3, in hub of disc SC-5, P. 3. This releases both discs and they may be pulled from shaft.

INSTRUCTION NO. 22.—TO RELEASE GRIPPING DISC SPRING SC-11, P. 6, follow Instruction No. 20, after which drive taper pin from pinion on end of shaft. Pull pinion off, which releases spring.

INSTRUCTION NO. 23.—TO REMOVE PINION FROM GRIPPING DISC SHAFT SC-1, P. 3, follow Instruction No. 22.

INSTRUCTION NO. 24.—THROW-OUT LEVER SC-13,P. 6, located just at inner surface of gripping disc, is for the purpose of releasing gripping disc pinion from gear CS-124, P. 6. The gripping discs should be thus released when operating mechanism by means of the crank.

INSTRUCTION NO. 25.—TO REMOVE TOGGLE CASTING, shown, removed from mechanism, as CS-117, P. 5, first follow Instruction No. 20, then loosen two screws CS-121, P. 5, and two screws CS-129, P. 2, and shove out the bronze spindle bushing CS-122, P. 2.

INSTRUCTION NO. 26.—TO DISASSEMBLE TOGGLE UNIT, shown removed from mechanism and posed in lower right-hand corner of P. 5, first follow Instruction No. 25, then remove screw CS-127, P. 5, which will release pulley CS-126, P. 5, and the two gears. To release shaft from casting remove nut CS-120, P. 5.

INSTRUCTION NO. 27.—THE CRANK, SF-48, P. 9, by means of which mechanism is operated by hand, engages with dowel pin SF-20, P. 3, by means of a ratchet. It is held in place on shaft by screw SF-49, in end of shaft—not shown in plates.

INSTRUCTION NO. 28.—Pilot light PL-15, P. 5, is for the purpose of lighting interior of mechanism and for threading in frame. It is automatically lighted by opening the right hand mechanism casing door. The switch is located in the fibre base of the lamp, which is operated by means of a two-cell dry battery located on rear wall of upper magazine. When right hand casing door is closed lamp is automatically switched off.

INSTRUCTION NO. 29.—TO REMOVE THE AUTOMATIC FIRE SHUTTER GOVERNOR, SF-69,P.4, follow instruction No. 1, which removes film gate. Next remove governor lever CS-153,P.5, by removing slotted nut CS-157, P.5, located on top of frame casting, behind magazine. Next remove the two hexagon nuts, SF-82,P.3, in end of shaft, which passes through governor unit, and remove hexagon nut SF-83,P.5, whereupon entire governor unit will be released.

INSTRUCTION NO. 30.—TO DISASSEMBLE AUTOMATIC FIRE SHUTTER GOVERNOR—First follow Instruction No. 29, then remove two screws, which hold casing SF-77, lower right corner, P. 6, to governor unit, and take casing off. To release governor weights, inside of unit, it is only necessary to drive out the hinge pins, in either direction, they being non-taper pins.

INSTRUCTION NO. 31.—TO REMOVE REVOLVING SHUTTER SUPPORTING UNIT, shown posed on top of mechanism casing, CS-44, P. 6, take out the four screws separately numbered CS-43, P. 3, which releases the entire unit.

INSTRUCTION NO. 32.—TO DISASSEMBLE REVOLVING SHUTTER UNIT, shown removed from mechanism and posed in two positions, CS-44, in P. 3 and P. 6, first follow Instruction No. 31. Next loosen screw CS-52, P. 3, in collar of universal shutter mount, which will release both the mount

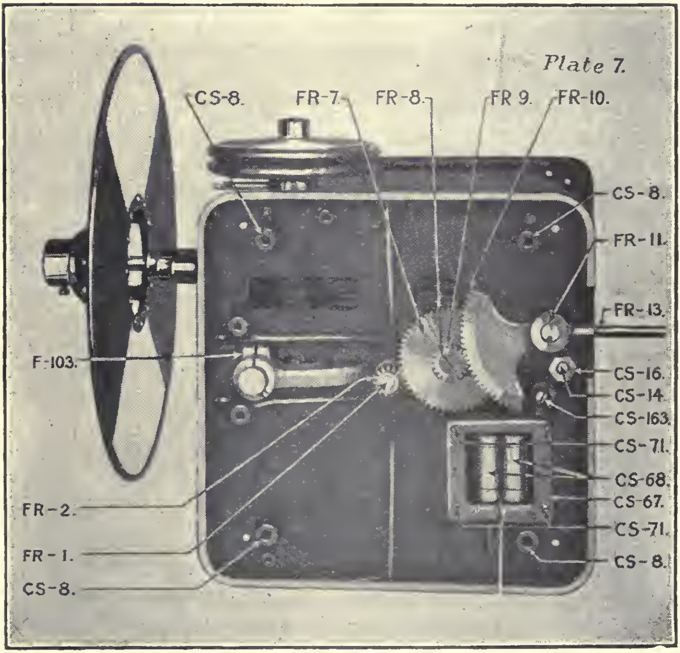


Plate 7, Figure 281.

and the shutter shaft. To release shutter drive shaft, CS-53, P. 3, loosen screw in collar CS-53. To release shutter shaft and shutter driving shaft bushings loosen the set screw which holds each, first, of course, having removed the shafts themselves. To remove pinion CS-49, P. 6, and pinion it meshes with, first remove the shafts themselves from their bushings, and then drive out the taper pins by means of

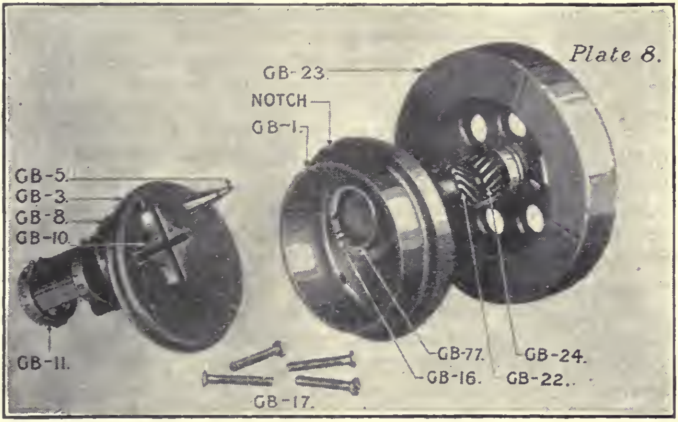


Plate 8, Figure 282.

which gears are locked to shaft. Disc CS-55, P. 6, may be removed by driving out the taper pin which holds it.

INSTRUCTION NO. 33.—TO REMOVE SHUTTER DRIVE SHAFT BEARING SF-2, P. 4 and 6, first follow Instruction No. 6 and then remove double gear SF-22 and 23, by taking out screw SF-26, P. 6. Next remove the two screws SF-17, P. 6 (arrow only points to one. Other is ¼ inch to left) and the bearing will be released.

Disc SF-6 and Pinion SF-5 are secured to shaft by taper pins. The bronze bearings in which the shaft revolves are driven in at either end. They are not intended to be replaced. When worn it is necessary that a new bearing complete be ordered and installed.

INSTRUCTION NO. 34.—TO REMOVE DIAGONAL SHAFT SF-62, P. 6, remove the two screws (SF-68) which hold the bearing at either end of shaft, which releases both bearings and shaft.

INSTRUCTION NO. 35.—ADJUSTING, SETTING OR TIMING REVOLVING SHUTTER. First carefully study general Instruction No. 22 until you thoroughly understand the principles involved. In the Motiograph DeLuxe Model a universal mount is used in order to enable the removal and replacement of the revolving shutter without readjustment, or re-setting. The small hexagon nut on front end of hexagon collar is used to clamp the disc carrying pin CS-64, lower right corner, P. 3, in position to secure rough adjustment of shutter, the finer adjustment being secured by turning knob CS-180, P. 4, at top left-hand corner of mechanism. The knurled knob at top of rod CS-181, P. 3, is held to rod by a set screw which engages a flat spot on rod, and collar CS-183, P. 3, is held to shaft by set screw, which also engages with flat spot on shaft. End-shake, or movement of rod is prevented by use of adjusting nut CS-184, P. 3, and check nut CS-185, P. 3.

INSTRUCTION NO. 36.—TO ATTACH REVOLVING SHUTTER TO ITS SHAFT, dowel pin CS-64, P. 3, must enter hole in collar of shutter, and the shutter be clamped in place by screw CS-172, P. 3, in hub of shutter. The revolving shutter blade is carried by a sort of cradle, the hub of which is CS-171, P. 3. This is an excellent arrangement in that it permits of the blade being placed right up against the front plate of the mechanism—as close to lens as it is possible to get it—in the case of very short focal length projection lens, whereas when a very long E. F. projection lens is used the shutter may be reversed and actually made to be some distance beyond the end of the shutter shaft. Under some conditions this is a very valuable feature, in that it permits of a virtual lengthening of the shutter shaft.

INSTRUCTION NO. 37.—TO RELEASE SHUTTER ADJUSTING SHAFT CS-181, P. 3, from shutter supporting unit, remove screw from opposite end of stud CS-65, P. 3, and to release shaft CS-181, P. 3, from frame of mechanism casing loosen screw which locks knob CS-180, P. 4, to shaft, having first released shaft from shutter supporting unit.

INSTRUCTION NO. 38.—TO REMOVE SLIDING MECHANISM FRAME, which is the vertical sliding frame which carries most of the gearing and other parts, first follow Instruction No. 17, then take off the front plate by removing two screws, one at either front top corner of mechanism casing, and two screws from the inside of lower corners of the front plate (front plate is plate which is next screen), which screw into the base; also a large screw in the middle front of top plate. This latter screw engages the large round rod on the frame slides. Next remove lens barrel bracket by taking out three screws CS-31, P. 6, and two screws, not shown, which secure other end of bracket to round slide rod CS-13, P. 6.

INSTRUCTION NO. 39.—TO REMOVE THE FRAMING PARTS, which are located on under side of base of mechanism, remove gear segment FR-10, P. 7, by driving out the taper pin which secures gear segment to stud FR-11, P. 7. Having done this you may then remove double gear FR-7, FR-8, P. 7, by taking out screw FR-9, in center of stud on which gear rides. Pinion FR-2, P. 7, is removed by driving out taper pin which secures it to framing screw FR-I, P. 7. Framing handle FR-13, P. 7, is removed by screwing it out, using a plier if necessary, lining its jaws with paper to prevent scarring handle.

INSTRUCTION NO. 40.—BALANCING AND TENSION OF MECHANISM FRAME. The mechanism frame is balanced by spring SF-41, P. 6. The tension of this spring is adjusted by a slotted screw nut located back of top magazine and about two inches from front of mechanism frame. The tension of the sliding frame is regulated by two screws, SF-103, P. 6 and 7, which clamp the sliding frame to the round slide rod, CS-13, P. 7. The rear of the sliding frame is guided by the square slide rod, CS-14, P. 3, and 6 and the guides are adjusted to the square rods by two screws, SF-106, P. 6, one near top and one near bottom. These screws should be only tight enough to prevent any vibration or shake of sliding frame and the tension (ease of sliding) should be regulated by screws SF-103, P. 6, which latter should be set just tight enough to prevent the sliding frame from "crawling" when the projector is in operation. If too loose the frame will crawl. If too tight the framing handle will work too hard.

INSTRUCTION NO. 41—THE SPEED CONTROL. The driving disc is mounted directly on the motor shaft, and is held in place by a set screw. The speed of projector mechanism is altered by rocking the motor on the shaft of the motor support, SC-20, P. 9. Attached to shaft of motor support, SC-20, P. 9, is an arm, SC-22, which is held in place by two screws, SC-25, P. 9. On the end of the arm is a roller, SC-23, P. 9, held in place by a screw in center of roller bearing. This roller engages with a cam, SC-34, P. 9, attached to shaft SC-30, P. 9, by set screw SC-35, P. 9. Handle SC-29, P. 9, is the speed control lever, or handle. SC-19, P. 4, is an armored electric circuit extending to motor through motor support bracket SC-20, P. 9.

INSTRUCTION NO. 42—LUBRICATION. See general Instruction No. 1, in addition to which the manufacturer advises that they furnish a special heavy oil designed for use in the oil well of the intermittent movement, and a special grease gun is supplied with each Motiograph installation with which to inject the oil. The opening for injecting the oil is about three-quarters of an inch to the right of the locating notch in the top of the box, or oil well, on the left side of the sliding frame. "Geneva Lubricating Grease" is supplied in either three-ounce or one-pound cans.

FOR SLIDING DISC SHUTTER CONNECTION a

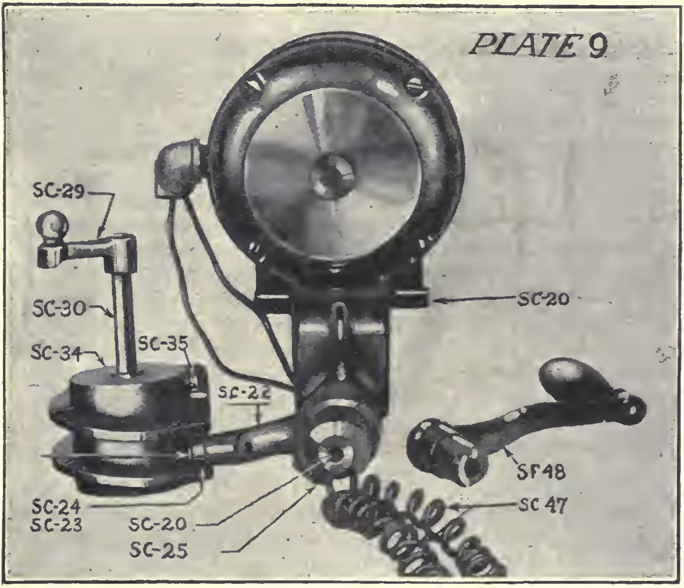


Plate 9, Figure 283.

heavier grease, called "Disc Grease," should be used. It may be had of the projector manufacturer in either three-ounce or one-pound cans.

We recommend that you order these lubricants and use them for the purposes named.

THE SPEED CONTROL DISCS should be given a drop of oil occasionally.

THE INNER END OF SPEED CONTROL SHAFT is lubricated by an oil tube located about the center of the lower front part of the mechanism casing, on the outside. It is of vital importance that you do not overlook this oiling place. There is an oil hole in the pinion sleeve back of the governor. Do not overlook it. The hole in center of take-up pulley screw CS-127, P. 6, is an oil hole.

NOTE.—The Enterprise Optical Company, manufacturers of the Motiograph, issue an instruction book, which will be sent you free upon application.

INSTRUCTION NO. 43—TO ADJUST PROJECTOR FOR ANGULAR PROJECTION—Loosen two clamp bolts, P. S. 252, P. 10, and turn hand screw P. S. 250 to the right or to

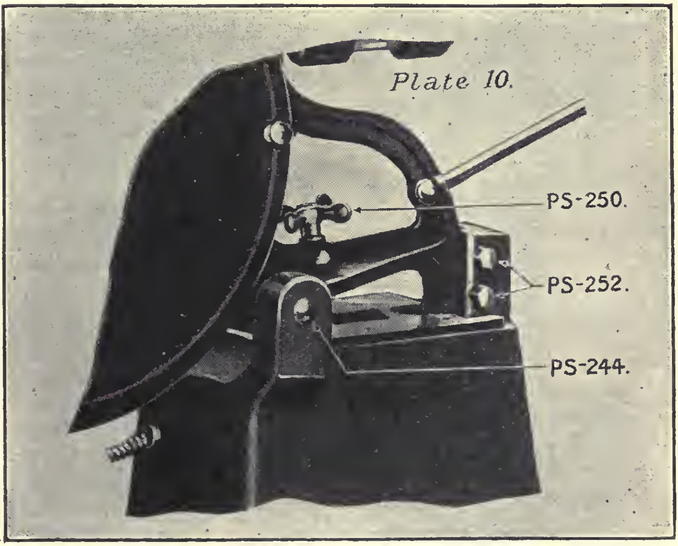


Plate 10, Figure 284.

the left to raise or lower rear end of projector until desired angle is had, after which tighten clamp bolts P. S. 252.

CAUTION.—Never attempt to change the projector angle by means of hand screw P. S. 250 until the clamp bolts have been loosened.

PARTS FOR MOTIOGRAPH.—De Luxe Model.

NOTE.—Order by number and description, but do not omit the number. The numbers are the manufacturers stock number.

Plate	No.	Description.
—	CS-1	Base.
—	CS-2	Top.
—	CS-3	Front plate.
2	CS-4	Film gate.
4	CS-5	Left side rear door.
4	CS-6	Left side door.
—	CS-7	Right side door.
7	CS-8	Screw to hold mechanism to lower magazine.
—	CS-9	Hinge stud for film gate.
—	CS-10	Screw for hinge stud.
—	CS-11	Stud to guide lens barrel.
—	CS-12	Nut for stud CS-11.
6	CS-13	Round tie rod.
3-6-7	CS-14	Square tie rod.
—	CS-15	Screw for round and square tie rod.
7	CS-16	Nut for square tie rod.
5	CS-17	Door latch pin (short).
—	CS-18	Door latch pin (long).
5	CS-19	Gate Latch pin.
2	CS-20	Gate hinge knob (short).
—	CS-21	Door latch knob (long).
—	CS-22	Door latch spring (short).
5	CS-23	Door latch spring (long)
—	CS-24	Door hinge pin.
—	CS-25	Screw in gate for stop rod.
—	CS-26	Screw to clamp front plate to tie rod, 7-8x8x32.
—	CS-27	Screw to hold front plate to top and bottom.
3	CS-28	Screw to retain motor drive bushing.
—	CS-29	Cross bracket.
—	CS-30	Bracket screw for round rod.
6	CS-31	Bracket screw for square rod.
—	CS-32	Stop in for intermittent tension shoe.
2	CS-33	Latch for film gate.
—	CS-34	Collar for gate latch No. 33.
—	CS-35	Screw for gate latch No. 33.
—	CS-36	Glass for right side door (top).
—	CS-37	Glass for right side door (left side).
—	CS-38	Glass for right side door (right side).
—	CS-39	Glass for left side door.
—	CS-40	Retainer clip for glass.
—	CS-41	Screw for retainer clip.
3-6	CS-42	Retainer ring for shutter bracket.
3	CS-43	Screw to hold retainer ring.
6-3	CS-44	Shutter bracket.
3	CS-45	Screw to retain shutter bracket bushing.
—	CS-46	Bushing for shutter shaft.
—	CS-47	Bushing for shutter shaft drive.
3-4	CS-48	Shaft for shutter.
6-3	CS-49	Pinion on shutter shaft
—	CS-50	Taper pin for shutter pinions.
—	CS-51	Collar on shutter shaft Hex.
3	CS-52	Screw in shutter shaft collars.
3	CS-53	Shaft for shutter drive.
—	CS-54	Pinion on shutter drive shaft.
3-6	CS-55	Disc on shutter drive shaft.
—	CS-56	Taper pin in discs.
3	CS-57	Collar on shutter drive shaft.
—	CS-58	Dowel screw for front plate.
—	CS-59	Screw for shutter bracket friction.
—	CS-60	Plug for shutter bracket friction.
—	CS-62	Flange for shutter shaft collar.
—	CS-63	Hex. nut for shutter shaft collar.
3	CS-64	Pin to locate shutter.
3-6	CS-65	Stud for shutter adjusting rod in bracket.
—	CS-66	Screw to retain shutter adj. rod stud.
7	CS-67	Fire trap.
7	CS-68	Roller for fire trap.
—	CS-69	Bushing for fire trap roller.
—	CS-70	Shaft for fire trap roller
7	CS-71	Screw to hold fire trap to base.
5	CS-72	Rack lever for fire shutter.
—	CS-73	Rack for fire shutter.

Plate	No.	Description.
—	CS-74	Rivet for rack and hook on door stop.
5	CS-75	Bearing for rack lever.
—	CS-76	Rivet for rack lever bearing.
2	CS-77	Stud to operate fire shutter.
—	CS-78	Washer for bearing screw.
5	CS-79	Screw in rack lever bearing.
—	CS-80	Fire shutter plate, gear side.
—	CS-81	Pinion on fire shutter.
—	CS-82	Shaft for fire shutter.
—	CS-83	Fire shutter plate, collar side.
—	CS-84	Collar on fire shutter.
—	CS-85	Rivet for fire shutter.
5	CS-86	Metal heat shield in side gate.
—	CS-87	Stop stud for fire shutter.
5	CS-88	Screw to hold heat shield.
—	CS-89	Stop Stud for fire shutter in door.
—	CS-90	Heat shield asbestos.
—	CS-91	Screw for heat shield.
5	CS-92	Film tension plate.
5	CS-93	Roller on tension plate.
5	CS-94	Shaft for roller.
—	CS-95	Spring for intermittent sprocket shoe.
5	CS-97	Gate slide.
—	CS-98	Clip for gate slide.
—	CS-99	Rivet for clip.
—	CS-100	Locating stud in gate slide.
5	CS-101	Film guide roll, spring end.
5	CS-102	Film guide roll, plain end.
—	CS-103	Spring for guide roll.
5	CS-104	Shaft for guide roll.
5	CS-105	Tension shoe (long).
—	CS-106	Spring for tension shoe (long).
5	CS-107	Tension shoe (short).
—	CS-108	Spring for tension shoe (short).
6	CS-109	Screw for tension shoe.
—	CS-110	Tension shoe for intermittent sprocket, outside
—	CS-111	Spacing collar for tension shoe.
—	CS-112	Tension shoe for intermittent sprocket, inside.
—	CS-113	Spacing rod for tension shoe.
—	CS-114	Collar between gate slide and tension plate.
6	CS-115	Screw to hold tension plate to gate slide.
5	CS-116	Screw to hold gate slide to gate.
5	CS-117	Toggle casting.
—	CS-118	Toggle gear shaft.
—	CS-119	Washer on toggle gear shaft.
5	CS-120	Nut on toggle gear shaft
5	CS-121	Screw to clamp toggle casting.
2-5	CS-122	Bushing in toggle casting.
5-6	CS-123	Gear on toggle shaft, steel.
5	CS-124	Pinion on toggle shaft, steel.
—	CS-125	Key pin in pinion.
5-6	CS-126	Take-up pulley.
5-6	CS-127	Screw in toggle gear shaft.
2	CS-129	Screw in tension plug.
—	CS-130	Lens focusing bracket.
—	CS-131	Dowel pin for focusing bracket.
—	CS-132	Shaft for focusing bracket.
—	CS-133	Pinion in focusing bracket.
—	CS-134	Pin to hold pinion No. 133 to shaft.
5	CS-135	Thumb knob for focusing bracket.
—	CS-136	Wing for knob No. 135.
—	CS-137	Screw to hold focusing knob to shaft.
—	CS-138	Screw to hold focusing bracket.
5	CS-139	Lens barrel, rear.
3	CS-140	Stud for aperture plate.
6	CS-141	Screw to hold lens barrel to bracket.
—	CS-142	Glass in lens barrel.
—	CS-143	Retainer ring for lens barrel glass.
5	CS-144	Tube between lens barrels.
—	CS-145	Screw to hold tube to barrel.
2-5	CS-146	Lens barrel front.
—	CS-147	Bushing in lens barrel.
2	CS-148	Screw to clamp lens barrel.
—	CS-149	Lens adapter.
—	CS-152	Lens focusing screw rod.
5	CS-153	Governor lever.
—	CS-154	Bushing for lever No. CS-153.
5	CS-155	Rod for lever No. CS-153.
—	CS-156	Screw shaft for lever No. CS-153.
5	CS-157	Nut to hold lever to top.
2-3-5	CS-158	Stop rod for film gate.
—	CS-159	Hook in end of stop rod.
3	CS-160	Friction stud for stop rod.
—	CS-161	Ball in friction stud.
—	CS-162	Spring in friction stud.
7	CS-163	Screw in friction stud.
2	CS-164	Cover for crank opening.
—	CS-165	Dowel pin for cover No. CS-164.
3	CS-166	Screw for cover No. CS-164.
—	CS-167	Shutter, 3 blade.
3-4	CS-168	Shutter, 2 blade.
3	CS-169	Shutter hub.
3	CS-170	Screw to hold shutter to hub.
3-4	CS-171	Collar for shutter hub.

Plate	No.	Description.
3	CS-172	Set screw for shutter collar.
—	CS-173	Screw to locate shutter hub.
—	CS-174	Light shield.
—	CS-175	Glass retainer strip for shield.
—	CS-176	Rivet for glass retainer.
—	CS-177	Clip to hold shield to gate.
—	CS-178	Screw to hold shield to gate.
—	CS-179	Ruby glass for shield.
4-6	CS-180	Thumb knob for set shutter.
3-6	CS-181	Screw rod to set shutter.
3	CS-182	Screw to hold knob to screw rod.
3-6	CS-183	Collar for shutter setting screw rod.
3-6	CS-184	Thrust sleeve.
3-6	CS-185	Lock nut for thrust sleeve.
—	CS-186	Oil tube for drive shaft.
—	CS-187	Screw to hold oil tube.
—	CS-188	Collar for Int. spkt. shoe spring.
—	CS-189	Washer for int. spkt. shoe spring.
—	CS-190	Screw to hold front to base vrt.
5	CS-246	Fire shutter, complete.
2	CS-247	Fire trap, complete.
2	CS-248	Light shield, complete.
5-6	CS-249	Inter. sprocket shoe, complete.
—	CS-250	2 wing shutter, complete.
—	CS-251	3 wing shutter, complete.
—	SF-1	Sliding frame.
4-6	SF-2	Bearing shutter drive shaft.
—	SF-3	Bushing for shutter drive shaft.
6	SF-4	Shutter drive shaft.
6	SF-5	Pinion on shutter drive shaft.
6	SF-6	Disc on shutter drive shaft.
—	SF-7	Taper pin for pinion and disc.
—	SF-8	Bushing for upper and lower sprocket shaft.
—	SF-9	Bushing for crank shaft.
6	SF-10	Screw to clamp geneva box.
6	SF-11	Stud to locate geneva box.
6	SF-12	Clamp for geneva box.
—	SF-13	Clamp pin for geneva box.
—	SF-14	Screw for balance spring.
—	SF-15	Key pin for gears.
6	SF-17	Screw for shutter drive bearing.
6	SF-18	Main gear. steel.
—	SF-19	Crank shaft.
3	SF-20	Pin in crank shaft.
3-6	SF-21	Thumb screw in crank shaft.
6	SF-22	Double gear, steel.
6	SF-23	Pinion on double gear, steel.

Plate	No.	Description.
—	SF-24	Pinion to drive angle shaft.
—	SF-25	Double gear shaft.
6	SF-26	Screw to retain double gear on shaft.
2	SF-27	Screw to retain shaft 25 in frame.
3	SF-28	Aperture plate.
2	SF-30	Roller bracket, upper.
2	SF-31	Roller bracket, lower.
—	SF-32	Shaft for roller brackets.
2-4-5-6	SF-33	Screw in roller bracket shaft.
—	SF-34	Taper pin to hold bracket to shaft.
—	SF-35	Screw to clamp roller shaft.
—	SF-36	Stud for roller bracket spring.
2-5	SF-37	Spring for roller brackets.
—	SF-38	Film roller shaft.
2-5	SF-39	Film roller.
2	SF-40	Thumb screw for roller shaft.
6	SF-41	Balance spring.
—	SF-42	Screw bushing in end of spring.
—	SF-43	Screw for adjusting spring.
5	SF-44	Stripper plate.
—	SF-45	Shaft for stripper plate.
—	SF-46	Screw for stripper plate.
—	SF-47	Screw for stripper plate shaft.
9	SF-48	Crank.
5	SF-49	Retaining screw for crank.
—	SF-50	Stud for crank handle.
—	SF-51	Handle for crank.
—	SF-52	Washer for crank handle.
—	SF-53	Screw for crank handle.
6	SF-54	Floating disc.
5	SF-55	Link for toggle.
5	SF-56	Screw for toggle link.
2	SF-57	Track support.
3	SF-58	Track, right side.
3	SF-59	Track, left side.
3	SF-60	Screws to tracks.
6	SF-61	Screw to hold track support to frame.
6	SF-62	Diagonal shaft.
—	SF-63	Pinion governor drive.
—	SF-64	Pinion upper sprocket drive.
—	SF-65	Taper pin for diagonal shaft pinions.
—	SF-66	Bushing for diagonal shaft.
—	SF-67	Cap for diagonal shaft bushing.
6	SF-68	Screw for cap No. SF-67.
4-6	SF-69	Governor support collar.
3-6	SF-70	Pinion on governor.
6	SF-71	Governor weight.
6	SF-72	Ball stud for governor weight.
—	SF-73	Governor shaft in frame.
—	SF-74	Governor weight collar.
—	SF-75	Pivot pin for governor weight.

Plate.	No.	Description.
—	SF-76	Spring for governor weight.
6	SF-77	Governor case.
6	SF-78	Screw in governor case.
5-6	SF-79	Shaft in governor wght. collar.
6	SF-80	Ball on end of shaft No. SF-79.
—	SF-81	Rivet to hold ball on shaft No. SF-79.
3	SF-82	Nuts for collar shaft No. SF-79.
5-6	SF-83	Nuts to hold governor shaft in frame.
3-5	SF-84	Link for gate slide.
—	SF-85	Nut for gate slide link.
5	SF-86	Ecc. stop for roller bracket.
—	SF-87	Lock stud for eccentric stop.
5	SF-88	Feed and take - up sprocket.
—	SF-89	Shaft for feed sprocket.
6	SF-90	Shaft for take-up sprocket.
—	SF-91	Screw for feed and take-up sprocket.
6	SF-92	Feed sprocket pinion.
3-6	SF-93	Take-up sprocket pinion.
3	SF-94	Screw for sprocket pinions.
—	SF-95	Film footage counter bracket.
—	SF-97	Screw to hold counter to bracket.
—	SF-98	Pinion on counter.
3	SF-99	Counter pinion main shaft.
—	SF-100	Screw to hold counter pinion on shsft.
—	SF-101	Screw to hold counter bracket to frame.
6	SF-102	Friction screw in frame for square rod.
6-7	SF-103	Friction screw in frame for round rod.

UPPER MAGAZINE.

Plate.	No.	Description.
—	UM-200	Governor, complete.
	UM-201	Spider for upper magazine.
2	UM-202	Screew to hold spider to machine.
	UM-203	Magazine bottom.
	UM-204	Magazine band.
	UM-205	Rivets for magazine band.
	UM-206	Magazine door.
	UM-207	Hinge on body.
	UM-208	Hinge on cover.
	UM-209	Hinge pin.
	UM-210	Screw in door hinge.
	UM-211	Nut for hinge screws.
	UM-212	Screw for body hinge.
	UM-213	Wired glass circle.
	UM-214	Frame for glass circle.
	UM-215	Screw for frame.
	UM-216	Nut for frame.
	UM-217	Reel shaft.
	UM-218	Collar on reel shaft.
	UM-219	Staple on reel shaft.
	UM-220	Plunger for reel shaft.
	UM-221	Spring for reel shaft plunger.
	UM-222	End of reel shaft.
	UM-223	Pin in end of reel shaft.
	UM-224	Thumb nut on reel shaft.
	UM-225	Screw to retain thumb nut.
	UM-226	Brake spring.
	UM-227	Brake pad.
	UM-228	Brake pad rivets.
	UM-229	Brake spring screw.
	UM-230	Brake spring wssher.
	UM-231	Door knob.
	UM-232	Stud for door latch.
	UM-233	Door latch.
	UM-234	Spring for door latch.
	UM-235	Collar for door latch.
	UM-236	Screw for door latch collar.
	UM-237	Door catch.
	UM-238	Screw for door catch.
	UM-239	Screw for door catch.
	UM-240	Nut for door catch screw.
	UM-241	Fire trap roller.
	UM-242	Bushing for fire trap roller.
	UM-243	Shaft for fire trap roller.
	UM-244	Screw to hold magazine to spider.
	UM-245	Felt washers between magazine and spider.
4	UM-275	Upper magazine complete, less spider.

FRAMER.

Plate.	No.	Description.
2-7	FR-1	Framer screw.
7	FR-2	Pinion on framer screw.
—	FR-3	Taper pin for framer pinion.
—	FR-4	Yoke for framer screw.
—	FR-5	Screw for framer yoke.
—	FR-6	Dowel pins for yoke.
7	FR-7	Gear for framer.
7	FR-8	Pinion on framer gear No. FR-7.
7	FR-9	Screw shaft for framer gear.
7	FR-10	Framer gear segment.
7	FR-11	Stud for segment No. 10.
—	FR-12	Taper pin for segment No. 10.
3-7	FR-13	Framer handle.

TAKE UP.

Plate.	No.	Description.
—	TU-1	Bracket for take - up spindle.
—	TU-2	Screw to hold bracket to msgazine.
—	TU-3	Shaft for take-up.
—	TU-4	Collar on take-up shaft.
—	TU-5	Staple on take-up shaft.
—	TU-6	Spring in take-up shaft.
—	TU-7	Plunger in take-up shaft.
—	TU-8	End of reel shaft.
—	TU-9	Pin to hold end to shaft.
—	TU-10	Ball bearing cone.
—	TU-11	Screw for ball bearing cone.
—	TU-12	Housing for ball bearing
—	TU-13	Steel ball.

Plate.	No.	Description.
—	TU-14	Fibre washer.
—	TU-15	Idler pulley arm.
—	TU-16	Idler pulley.
—	TU-17	Screw shaft for idler pulley.
—	TU-18	Take-up pulley.
—	TU-19	Nut to hold pulley to shaft.
—	TU-20	Idler adjusting screw rod.
—	TU-21	Screw to hold adjusting rod to arm.
—	TU-22	Thumb knob for adjusting screw rod.
—	TU-23	Stem for thumb knob.
—	TU-24	Nut to hold housing to bracket.
—	TU-25	Take-up belt.
—	TU-26	Lacing for take-up belt.

PILOT LAMP.

5	PL-1	Fibre bracket for lamp.
—	PL-2	Contact for lamp switch (short).
—	PL-3	Contact for lamp switch (long).
—	PL-4	Fibre piece for contact.
—	PL-5	Rivets for fibre piece.
—	PL-6	Screw to hold contact to bracket.
—	PL-7	Top plate for lamp bracket.
—	PL-8	Bottom plate for lamp bracket.
—	PL-9	Screw to hold plate on bracket.
—	PL-10	Nut to hold plate on bracket.
—	PL-11	Fibre contact cover.
—	PL-12	Screw to hold contact cover.
—	PL-13	Lamp socket.
—	PL-14	Screw to bold lamp socket.
5	PL-15	Pilot lamp.
—	PL-16	Lamp cord.
—	PL-17	Bushing between lamp bracket.
—	PL-18	Screw to hold lamp bracket.
—	PL-19	Battery box.
—	PL-20	Top fibre piece for battery box.
—	PL-21	Bottom fibre piece for battery box.
—	PL-22	Rivet for top and bottom fibre.
—	PL-23	Cover catch pins.
—	PL-24	Back fibre piece for battery box.
—	PL-25	Cover for battery box.
—	PL-26	Knob for cover.
—	PL-27	Bushing between box and magazine.
—	PL-28	Screw to hold box to magazine.
—	PL-29	Nut to hold box to magazine.
—	PL-30	Clamp to hold wire to magazine.
—	PL-31	Screw to hold wire to magazine.
5	PL-100	Lamp bracket complete.

GENEVA BOX, OR INTERMITTENT MOVEMENT.

Plate	No.	Description.
8	GB-1	Inter. box.
—	GB-2	Bushing for cam shaft.
8	GB-3	Cover for geneva box.
—	GB-4	Stud for geneva box cover.
8	GB-5	Dowel pin to locate cover on box.
—	GB-6	Threaded bushing to clamp eccentric.
—	GB-7	Bushing to clamp eccentric.
5-6-8	GB-8	Screw for eccentric clamp bushing.
6	GB-9	Ecc. bushing.
8	GB-10	Geneva star.
5-6-8	GB-11	Intermittent sprocket.
—	GB-12	Taper pin in sprocket.
—	GB-13	Cam shaft.
—	GB-14	Cam.
—	GB-15	Taper pin to hold cam on shaft.
8	GB-16	Cam pin.
8	GB-17	Screw to hold cover to box.
6	GB-18	Stripper plate.
6	GB-19	Rod for stripper plate.
—	GB-20	Screw to hold stripper on rod.
—	GB-21	Screw to clamp stripper rod.
8	GB-22	Shutter drive pinion on geneva box.
4-8	GB-23	Fly wheel.
8	GB-24	Pinion on fly wheel.
4	GB-25	Key washer for fly wheel.
4	GB-26	Screw to hold fly wheel.
—	GB-27	Wrench for eccentric bushing.
—	GB-75	Geneva box, complete.
—	GB-76	Cover for geneva box with stud.
—	GB-77	Cam and shaft.

STEREOPTICON BRACKET.

4	SB-1	Stereo arm.
—	SB-2	Stereo lens ring.
—	SB-3	Stereo lens retainer ring.
—	SB-4	Swivel for lens ring.
—	SB-5	Screw for lens ring swivel.
—	SB-6	Screw to clamp swivel.
—	SB-7	Nut to clamp swivel.
—	SB-8	Screw to clamp lens rod.
—	SB-9	Rod for stereo lens ring.
—	SB-10	Vertical adj. screw for lens arms.
—	SB-11	Lock nut for vertical adj. screws.
—	SB-12	Support for lens arm.
—	SB-13	Nut for lens arm support.
4	SB-14	Focusing screw rod.
—	SB-15	Knob for focusing screw rod.
—	SB-16	Pin in knob No. 15.
—	SB-17	Screw in end of focusing rod.

SPEED CONTROL.

3	SC-1	Motor drive shaft.

Plate.	No.	Description.
—	SC-2	Pin in motor drive shaft.
—	SC-3	Pinion on motor drive shaft.
—	SC-4	Taper pin to hold pinion to shaft.
3	SC-5	Outer gripping disc.
3	SC-6	Fibre for gripping disc.
—	SC-7	Plate to hold fibre to disc.
—	SC-8	Screw to hold fibre to disc.
3	SC-9	Taper pin to hold gripping disc to shaft.
6	SC-10	Inner gripping disc.
6	SC-11	Spring to compress gripping discs.
6	SC-12	Spiral groove bushing.
6	SC-13	Lever pin for grooved bushing.
6	SC-14	Collar on inner disc hub.
3	SC-15	Screw in collar No. 14.
—	SC-16	Motor.
—	SC-17	Conduit elbow.
—	SC-18	Screw for conduit elbow.
4	SC-19	Conduit.
4-9	SC-20	Motor support, for 110 volt motor.
—	SC-21	Motor support, for 220 volt motor.
9	SC-22	Arm for motor support.
9	SC-23	Roller for motor support arm.
9	SC-24	Screw for motor support arm roller.
9	SC-25	Screw to clamp support arm to support.
—	SC-26	Pivot screw for support arm.
—	SC-27	Disc on motor.
—	SC-28	Screw for motor disc.
4-9	SC-29	Control lever.
9	SC-30	Control rod.
—	SC-31	Pin to hold control lever to rod.
—	SC-32	Dial plate.
—	SC-33	Screw for dial plate.
9	SC-34	Cam to control motor.
9	SC-35	Screw to hold cam to control rod.
—	SC-36	Conduit clamp.
—	SC-37	Screw to hold conduit to mag. wall.
—	SC-38	Nut to hold conduit to mag. wall.
—	SC-39	Screw to hold conduit to motor support.
—	SC-40	Motor switch.
—	SC-41	Push button for switch.
—	SC-42	Bushing for push button in mag.
—	SC-43	Spacing collar for switch (short).
—	SC-44	Spacing collar for switch (long).
—	SC-45	Screw to hold switch to mag.
—	SC-46	Nut to hold switch to mag.
9	SC-47	Wire cord from main to switch.
—	SC-48	Conduit from main to switch.
4	SC-49	Screw to hold motor to support.
—	SC-100	Gripping disc unit.

KNOWLEDGE IS POWER.

The Baird Projector

THE Baird projector was the first distinctly heavily built type of motion picture projector. Its lamphouse is of ample dimensions and its arc lamp is well designed and well made. The mechanism is of the "inclosed" type, the casing having been removed to show the mechanism in Figs. 286, 287 and 288. Fig. 285 supplies a general view of the projector, as well as all necessary dimensional measurements. The projector may be tilted to a 25 degree angle.

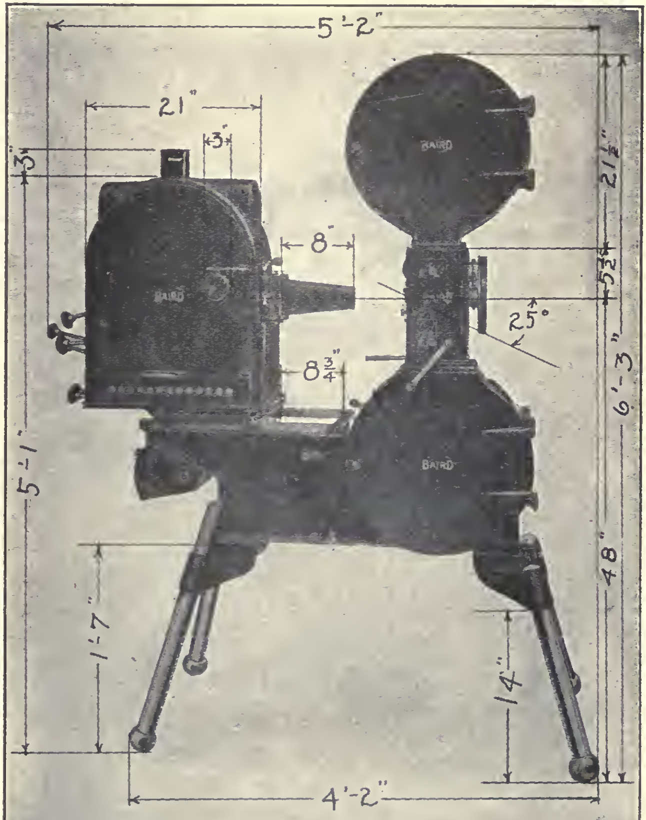
INSTRUCTION NO. 1.—To remove revolving shutter, 310P, P. 2, complete with its housing and lens tube 318P, P. 3, proceed as follows: Loosen screw 867P, P. 1, and pull the entire shutter, including its casing, straight out away from the machine. Shaft 312P, P. 2, which is hexagonal in shape, is not attached rigidly to the mechanism, but telescopes into the hexagonal hole in shaft 130P, P. 3.

INSTRUCTION 2.—In order to remove the casing of the projector mechanism, first follow Instruction No. 1, and then remove seven screws which secure the front casing to mechanism. This releases the entire casing from the mechanism, including two doors but not including the gate.

INSTRUCTION NO. 3.—To remove the cover for the shutter casing (not shown in the cut) grasp the cover and turn ¼ inch to the left. It will then be disengaged and can be pulled off.

INSTRUCTION NO. 4.—In order to remove shutter 310P, P. 2, drive out the taper pin in the hub and pull it off the shaft.

INSTRUCTION NO. 5.—To remove shutter shaft 312P, P. 2 and 3, follow Instructions Nos. 3 and 4, which will disclose a steel ring containing in its face three machine screws. Take out these screws and pull the ring off, which will release shutter shaft 312P, P. 2 and 3, and its ball bearing. Should it become necessary at any time to replace this ball bearing, you must order the shaft and bearing complete from the manufacturer, as the bearing is placed on the shaft under heavy pressure. The stock number of this shaft is 312P and of the ball bearing 320P. The replacing of this shaft is merely a reversal of the process of its removal but in replacing the steel ring (stock number 319P) be sure the ball bearing is properly centered before tightening down the three holding screws, else there may be vibration. The



The Baird Motion Picture Machine.

View of operating side, closed.

Note- Machine will tilt 17° Between this and 25°, the front legs must be sawed.

Figure 285.

best way to accomplish the centering is to put in the three holding screws, tighten them up and then back them off about one full turn. Now start the motor, and while the projector is running, grasp the steel holding ring between your thumb and finger, and you can tell by the sense of touch when it is properly centered; whereupon tighten up the three holding screws **tight.**

INSTRUCTION NO. 6.—The governor, the weight and parts of which are shown at 145P, P. 2, is held by two ball bearings clamped in the holding casting by screws 853P, P. 2.

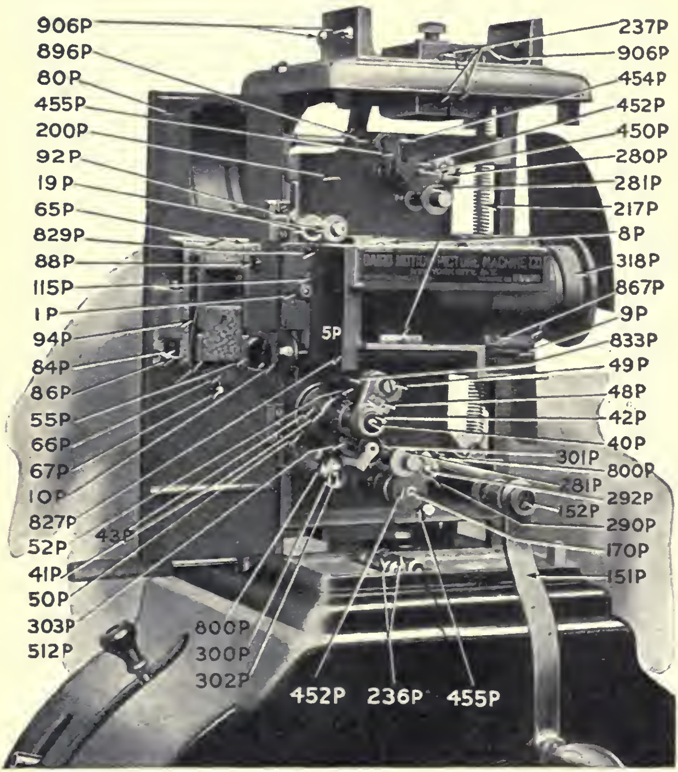


Plate 1, Figure 286.

The entire governor, including the ball bearings, may be removed as a unit by following Instructions Nos. 1 and 2. Then remove taper pin 70P, P. 2, and pull off arm 117P, P. 2. Next remove screw 141P, P. 2, and a similar screw immediately under the arrow head of 853P, P. 2; this releases bar 140P, P. 2. Next loosen screws 853P, P. 2, whereupon the entire governor including the ball races and beveled gear may be pulled out toward the front.

INSTRUCTION NO. 7.—To remove ball bearing 138P, P. 3, and spring 134P, P. 2, follow Instructions Nos. 1, 2 and 6, which release the governor as a unit. Now remove screw 822P, P. 2, and its mate on the opposite side and tap lightly on the end of shaft 130P, P. 3. The ball bearing is just a tight fit, and by tapping lightly on the end of the shaft with a copper or brass punch it will slip off the shaft, and thus releases the governor, weight, spring and sleeve.

INSTRUCTION NO. 8.—To remove spring 134P, P. 2, follow Instruction No. 7.

INSTRUCTION NO. 9.—To remove weight 145 P, P. 2, follow Instruction No.7, and then drive out the pins holding the governon-carrying arms. These pins are not tapered and may be driven either way.

INSTRUCTION NO. 10.—To remove ball race on inner end of governor shaft, follow Instruction No. 7, and then drive out taper pin in hub of gear 136P, P. 2. The large end of each taper pin used in this machine may be recognized by a file mark on the hub behind the head of the pin. Gear and ball race may now be driven off.

INSTRUCTION NO. 11.—To remove flywheel, 26P, P. 2, take out screw in end of shaft and carefully pry off the cap under it, whereupon the wheel may be pulled away. This also releases pinion 27P, P. 2 and 3.

INSTRUCTION NO. 12.—To remove bearing bracket 30P, P. 3, which is also the oil well cover, follow Instruction No. 11. Then pull off pinion 27P, P. 3, remove screws 867P (six of them), P. 2, whereupon the bracket including the cam 34P, P. 2, gear 33P, P. 2, and its shaft 25P, P. 2, can be pulled away as a unit. In removing this bracket pull the parts away carefully, moving them straight outward, then up and to the right, being careful not to strain any part, else you may injure the cam pin or the star or both.

INSTRUCTION NO. 13.—To remove cam 34P, P. 2, follow Instructions No. 11 and 12, and drive out taper pin engaging the hub of what appears to be gear 33P, P. 2, but is in reality the hub of the cam. This will release cam 34P, P. 2, and gear 33P, P. 2. Gear 33P, P. 2, is held to cam 34P, P. 2, by four screws in the back of the cam; by removing these screws the gear is released.

INSTRUCTION NO. 14.—Shaft 25P, P. 2, runs in a bronze bushing pressed into the bracket casting 30P, P. 3. This bushing may be driven out and a new one substituted. The new bushing may be driven in from either direction, but be very careful that you get it started straight, and do not use anything but a hard wood punch to drive it. Proceed carefully and you will have no trouble. The inner end of the bushing should be flush with the casting.

INSTRUCTION NO. 15.—To remove the intermittent unit, which includes shaft 40P, P. 2, star 44P, P. 2, bushing 42P, P. 2, eccentric sleeve 43P, P. 2, collar 45P, P. 2, and intermittent sprocket, 41P, P. 2, proceed as follows: Remove screw 49P, P. 1, and pull off bracket 48P, P. 1. Release screws 833P (two of them), P. 1, and take of intermittent stripper 52P, P. 1. Next remove screw 201P, P. 2. Then raise up on pin 50P, P. 1, which revolves eccentric sleeve 43P, P. 1, and disengages the star from the cam. The intermittent unit may now be removed by grasping the intermittent sprocket and pulling straight out.

INSTRUCTION NO. 16.—To remove intermittent sprocket 41P, P. 2, follow Instruction No. 15 and then drive out the two taper pins in the hub of the sprocket. See recommendation in Instruction No. 57.

INSTRUCTION NO. 17.—To remove both bushings 42P, P. 2, follow Instruction No. 15, drive out taper in the hub of star 44P, P. 2. Intermittent shaft may then be removed from sleeve 43P, P. 2. There are two bushings in this sleeve, and to remove them drive either one clear in against the other bushing and drive the old bushings right on through. In putting in new bushings use nothing but a hardwood punch and be sure to get them started straight. Drive the bushings in at either end of the sleeve until they are flush with the face of the sleeve. See recommendation in Instruction No. 57.

INSTRUCTION NO. 18.—The inner end of shaft 25P, P. 2. is carried by a small bronze bushing. To remove this bushing and tq replace proceed as follows: First follow Instruc-mittent mechanism. The hole which holds the bushing carrying the end of shaft 25P, P. 2, extends clear through to the other side, its open end being plugged up with a loosely fitting iron plug. Stick a steel nail or any slim punch through the bushing and drive this plug out. Then the bushing may be driven out from either end and the new one driven in. In driving in the new bushing use nothing but a hardwood punch, and be sure to get it started straight. The new bushing may be driven in from either end and its face must be flush with the casting on the inside end.

INSTRUCTION NO. 19.—Gear 176P, P. 2, and its shaft, gear 163P, P. 2; belt wheel 161P, P. 2; gear 158P, P. 2, and the shaft carrying them may be removed as a unit by first disconnecting the motor and the take up belts 659P and 334P, P. 4, and pulling out the hinge pins 338P and 660P, P. 4, then removing screws 872P, P. 2, and two others in the opposite end of Plate 181P. Next remove screw 152P, P. 1, and crank 151P, P. 1, and the taper pin in the shaft behind the hub of the crank. Next loosen screw on the inner end of shaft 455P, P. 1. This screw is on the gate side just between sprocket 452P, P. 1, and the casting. Having released the screws, turn down the stripper plate which comes up between the flanges of the sprocket, and then remove sprocket 452P, P. 1, by loosening the screw in the center of its hub and pulling the sprocket off its shaft; also pull off collar which is on the shaft behind sprocket, after loosening two set screws in its hub. This releases the parts. After having raised the framing carriage as far as it will go, grasp plate 181P, P. 2, and pull the whole thing straight out and away.

CAUTION.—In replacing this part be careful when you put the lower sprocket 452P, P. 1, back on the shaft that it centers properly between the flanges of the idler roller 281P, P. 1 (see Instruction No. 55), and that the stripper plate is raised up into position between the flanges of the sprocket, and its holding set screw well tightened.

INSTRUCTION NO. 20.—The method of driving the machine is as follows: When crank driven, gear 158P, P. 2, which is attached to take up belt pulley and to the crank shaft, drives pinion (stock No. 174) which is secured to the lower sprocket shaft 170P, P. 1. This pinion is just inside the plate 181P, P. 2, and does not show. It drives the lower sprocket shaft and gear 176P, P. 2 and 3 which in turn drives the cam shaft pinion 27P, P. 2 and 3.

When the projector is motor driven, motor pulley 625P,

P. 4, drives friction disc 622P, P. 4, which in turn drives belt 659P, P. 4. Belt 659P. P. 4, drives pinion 163P, P. 2, being attached to pulley 161P, P. 2. Pinion 163P, P. 2, drives lower sprocket shaft gear 176P, P. 2 and 3. Gear 176P, P 2 and 3, then drives the intermittent movement through pinion 27P, P. 2 and 3.

INSTRUCTION NO. 21.—To remove gear 176P, P. 2 and 3, drive out taper pin in its hub, remembering that the file mark

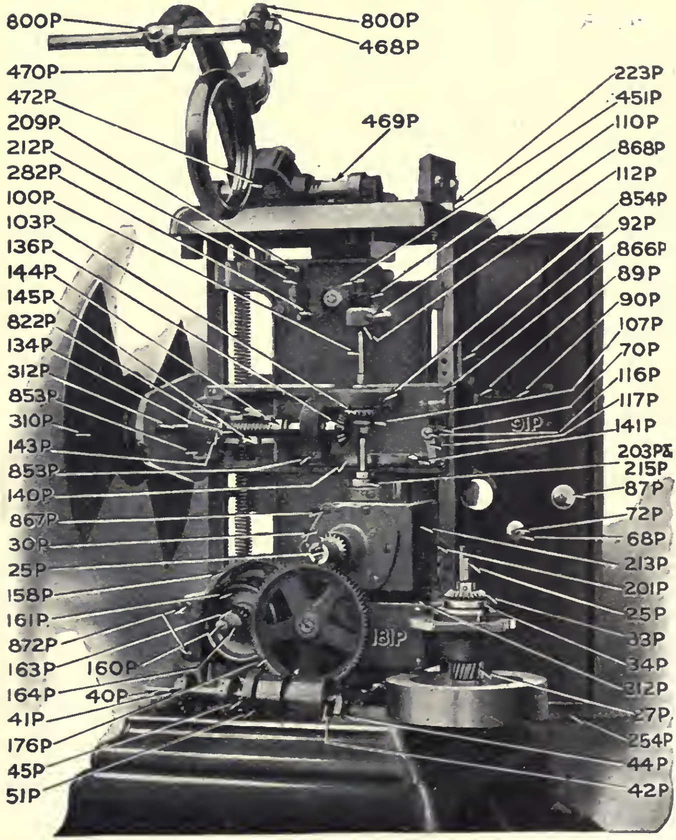


Plate 2, Figure 287.

on the hub is at the large end of the pin. Gear can then be pulled off the shaft.

INSTRUCTION NO. 22.—To remove lower sprocket shaft 170P, P. 3, and the inner pinion thereon, follow Instruction No. 19 and then drive out taper pin in hub of gear 176P, P. 2 and 3, whereupon the shaft can be pulled out on the operating side of the projector.

INSTRUCTION NO. 23.—To remove bronze bushing carrying lower sprocket shaft 170P, P. 1, follow Instruction Nos. 19 and 21, whereupon the bushing may be driven out from either direction, using a hard wood block and hammer for the purpose. In replacing this bushing take note that the bushing is longer than the bearing, and be careful that it projects or extends the same distance as the old one.

INSTRUCTION NO. 24.—To remove belt pulley 161P, P. 2 and gear 163P, P. 2, follow Instruction No. 21 and then loosen set screws (two of them), in collar 162P, P. 3, after which the pulley and gear can be removed.

INSTRUCTION NO. 25.—To remove gear 158P, P. 2, and the belt pulley attached thereto, follow Instruction No. 19 and remove collar 163P, P. 3, whereupon the shaft and gears can be pulled out. Gear 158P, P. 2 and 3, is attached to the crankshaft by means of a taper pin in its hub, and the belt pulley next it is also attached in the same manner.

INSTRUCTION NO. 26.—The crank end of the crankshaft is supported by a bronze bushing. To remove this bushing and replace it with a new one follow Instruction No. 19 whereupon the bushing may be driven out from either direction and the new one driven in, using only a hard wood block for the purpose.

INSTRUCTION NO. 27.—Just below the intermittent oil well in the main frame casting is one of the bushings supporting lower sprocket shaft 170P, P. 1. To remove this bushing and replace it with a new one follow instruction No. 19, whereupon the bushing may be driven out from either direction and the new one driven in, using a hardwood block for driving.

INSTRUCTION NO. 28.—The springs which hold the idler roller bracket to the sprocket are removed or attached merely by slipping them off the studs.

INSTRUCTION NO. 29.—To remove governor bracket 137P, P. 2 and 3, carrying governor and the center ball race of shaft 100P, P. 2 and 3, follow Instructions Nos. 1 and 2, then remove taper pin 70P, P. 2, and arm 117P, P. 2, and pull out shaft 116P, P. 2. Next remove screw 854P, P. 2, and shove upward on gear 103P, P. 2, thus raising both the gear and ball bearing above its supporting casting. Now remove screws 866P, P. 2 (four of them), whereupon part 137P, P. 2 and 3, can be pulled away, carrying with it the governor, gear 136P, P. 2, and link 140P, P. 2.

INSTRUCTION NO. 30.—To remove castings 1P, P. 1, and 2P, P. 3, which support the lens, follow Instruction No. 1, then take out taper pin 70P, P. 2, pull out shaft 116P, P. 2, and remove four screws, one at each corner of the casting, first pulling part 2P, P. 3, in by means of knob 10P, P. 1, far enough to expose the two screws in lens end of casting.

INSTRUCTION NO. 31.—To remove knob 10P, P. 1, and rod 9P, P. 1, look on the under side of casting immediately below rod 9P, P. 1, at the end next knob 10P, P. 1, and you will find a small screw. This screw engages a groove in shaft 9P, P. 1, and after it has been removed, rod 9P and knob 10P may be removed by screwing it out of the arm of part 2P, P. 3. In replacing this part do not forget to tighten up this retaining screw so that it engages with the groove in the shaft, or else the rod will not operate part 2P, P. 3.

INSTRUCTION NO. 32.—Part 2P, P. 3, is the casting which engages or grasps tube 318P, P. 3, which holds the lens. The lens tube itself rests inside part 318P, P. 3, so that when the parts are assembled and the lens is in place, part 318P, P. 3, and the lens tube are tightly clamped together by screw 867P, P. 1 and 3; and since part 318P, P. 3, carries with it shutter blade 310P, P. 2, and shutter shaft 312P, P. 2 and 3, it follows that by adjusting knob 10P, P. 1, the lens and the shutter blade are both moved inward and outward when the lens is focused, and thus the shutter is maintained at all times at a fixed distance from the lens.

INSTRUCTION NO. 33.—Top guide roller 19P, P. 1, is composed of inner flange 18P, P. 3, outer flange 20P, P. 3, and spreading rollers 19P, P. 1, these being held together by spindle 14P, P. 3, and spring 16P, P. 3. This part may be disassembled by removing set screws in the supporting casting just back of arrow head 18P, P. 3. The tension of spring 16P, P. 3, may be varied at will by loosening the holding set screw just back of arrow head 18P, P. 3, and moving shaft 14P, P. 3, slightly in or out.

INSTRUCTION NO. 34.—Aperture plate 5P, P. 1, is held in position by four screws. This plate is made of carbon steel as hard as glass. It may be removed for renewal by taking out four screws, one in each corner.

INSTRUCTION NO. 35.—To remove gate 80P, P. 1, take out the four screws holding the main casting to the posts and then pull the gate away. The hinges are held by dowel pins in addition to the screw.

INSTRUCTION NO. 36.—Automatic fire shutter flap 91P, P. 2, is attached to its shaft merely by being bent around it. Its position on the shaft may be adjusted by holding horizontal rack 88P, P. 1, stationary and lifting or lowering, as

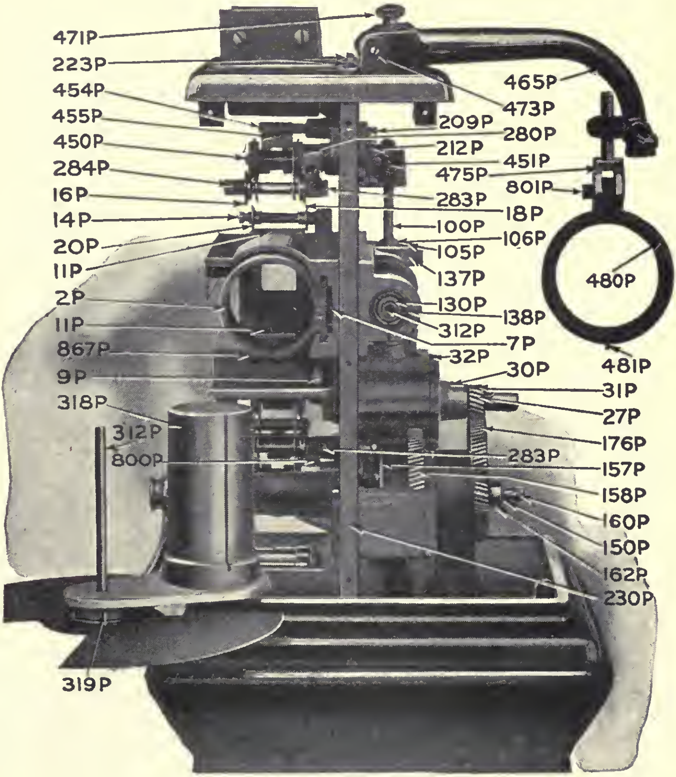


Plate 3, Figure 288.

the case may be, fire flap 91P, P. 2. Fire flap 91P, P. 2, may be removed by driving out the spindle from the pinion end. In replacing hold the corner of a hardwood block against the pinion and drive the shaft into the pinion, after having shoved the shaft through the fire flap. The rack engaging this pinion may be removed by driving it through the gate away from the pinion; use only a hardwood punch for this purpose, the door of course being open or off the projector. This rack should be kept clean and perfectly free at all times, since the shutter drops by gravity alone.

INSTRUCTION NO. 37.—Each of tension shoes 65P, P. 1, is pivoted to a plunger which passes through the gate casting, the shoes being held up against the film by a flat spring, the lower end of which is seen at 66P, P. 1. The tension on this spring is regulated by nut 68P, P. 2, which is attached to a steel screw 67P, P. 1. Thus the projectionist at all times is able to give his tension the finest possible adjustment. Spring 66P, P. 1, is so pivoted that it automatically equalizes the tension between the two shoes.

Lower tension shoes 55P, P. 1, are attached to plate 58P, P. 1, and are held up by a small flat yoke spring at its rear. Plate 58P, P. 1, and lower tension shoes 55P, P. 1, may be removed by taking out screw 878P, P. 1, on the upper end of the plate. Upper tension shoes 65P, P. 1, may be removed by pressing in on the lower end of the shoe until the upper end comes out of its engaging slot; turn upper end toward center of the gate. It will then be released from its pivot pin.

INSTRUCTION NO. 38.—Spring 94P, P. 1, is held by two screws at its lower end, and serves to hold the film over against the steel track at the left of the aperture. It also prevents side motion. The main tension spring supplies tension to the upper shoes. To remove this spring, remove screw 72P, P. 2, in the center of nut 68P, P. 2, taking off nut 68P, P. 2, and pulling out pin 67P, P. 1. In replacing the spring be sure that the depression in its face rests on the fulcrum properly and that its upper ends engage with the plungers of the tension shoes.

INSTRUCTION NO. 39.—Upper sprocket 452, P. 1, may be removed by loosening the screw holding stripper spindle 454P, P. 1 and 3. Swing the stripper up out of the way, loosen the set screw in the hub of the sprocket, and pull sprocket off. In replacing sprocket be careful to get it properly centered between the flanges of its idler rollers.

INSTRUCTION NO. 40.—Upper sprocket shaft 450P, P. 1 and 3, and gear 451P, P. 2 and 3, may be removed by following Instruction No. 39 and then removing collar 453, P. 1, by loosening set screws (two of them) in its hub, afterward pulling shaft and gear out.

INSTRUCTION NO. 41.—To remove gear 110P, P. 2, drive out the taper pin in its hub and raise the gear off by revolving it until it disengages from the teeth of 451P, P. 2 and 3.

INSTRUCTION NO. 42.—To remove shaft 100P, P. 2 and 3, remove screw in top of mechanism which engages main supporting spring 217P, P. 1, then remove nuts 223P, P. 3, and take out the two top screws holding mechanism case to the top of mechanism, which will allow the whole top of the mechanism to be taken off. Next release screw 854P, P. 2, and upper and lower screws 868P, P. 2. Now follow Instruction No. 12, look into the oil well and see the bevel gear on lower end of shaft, attached thereto by a taper pin, remembering that the file mark is at the large end of the pin. Drive this pin out. Next loosen two set screws in collar resting on part 203P, P. 2, and 215P, P. 2, whereupon shaft 100P, P. 2, may be lifted out upward.

INSTRUCTION NO. 43.—The mechanism is held to the lower magazine by four screws, the heads of which are seen by looking underneath the edge of the casting in the top of the lower magazine. Remove these four screws and you may lift the whole mechanism away.

INSTRUCTION NO. 44.—The framing of the carriage is accomplished by means of a segment of a gear and pinion attached to the side of the base of the mechanism. Should anything at any time go wrong with this mechanism you can get at it by removing the machine from the base, whereupon its method of disassembling is self-evident. The framing mechanism under the base operates a vertical screw 247P, P. 4, which engages with a phosphor bronze nut attached to the center of the framing carriage.

INSTRUCTION NO. 45.—The weight of the framing carriage is carried by a vertical spring 217P, P. 1, and if there is a tendency for the carriage to work down proceed as follows: Open the motor compartment door, and looking up at the bottom of the mechanism you will see a half round arrangement with a cap and three screws; this is open at one side. Looking in you will see a small nut which has a right-hand thread. By tightening this nut slightly the tension on the framing handle is increased. Later design has a plate supported by two lugs in place of the half round support, the adjustment being the same.

INSTRUCTION NO. 46.—Where it is desirable to use half-size lens the company furnishes a special mount with a revolving shutter. The half-size lens cannot be used with the regular mount as shown at 318P, P. 1 and 3.

INSTRUCTION NO. 47.—To remove motor drive unit disconnect wires leading to switch and remove belt 659P, P. 4, by taking out pin 669P, P. 4. Looking under casting 621P, P. 4, you will see a horizontal link connected to a vertical lever by a screw. Remove this screw. Next take off nut securing upper end of toggle link to casting 621P, P. 4. Remove screw 658P, P. 4. Motor unit may now be taken out as a whole. Motor may be removed from casting 621P, P. 4, by removing screws in bottom of casting 621P, P. 4, and screws in coupling 650P, P. 4.

INSTRUCTION NO. 48.—In order to remove driving friction wheel which bears on friction disc 622P, P. 4, first follow Instruction No. 47, then remove 638P, P. 4, from shaft 635P, P. 4. This key is held in position by a screw in its face. Next remove three screws in the face of the leather washer 633P, P. 4, which will release disc wheel.

INSTRUCTION NO. 49.—To remove the friction material on face 625P, P. 4, follow Instructions Nos. 47 and 48 and then remove screws in the outer end (you cannot see them in the cut) of the friction wheel. This releases the friction material, which may be removed and new material be secured from the manufacturer and put in its place. The friction material will need no turning or trueing up after being put in.

INSTRUCTION NO. 50.—To remove disc wheel 622P, P. 4, release the set screw in the belt pulley on the shaft of the disc, after first having released the screw in the rim of knurled adjusting nut on the rear end of the shaft. Back this nut off, whereupon you may pull the friction disc and shaft away.

INSTRUCTION NO. 51.—To adjust the intermittent sprocket and cam in order to eliminate lost motion in the intermittent, first loosen screw 201P, P. 2, and screw 49P, P. 1, after which slightly turn eccentric sleeve 43P, P. 1, by pressing down on projecting pin 50P, P. 1, at the same time revolving the flywheel by hand. When you think you have it just about right tighten up screw 201P, P. 2, and try the intermittent sprocket with your fingers. See General Instruction No. 5. When you have the adjustment made to your satisfaction tighten up screw 49P, P. 1, and the adjustment is completed.

CAUTION.—Should you, for any reason, remove bracket 48P, P. 1, be very sure that its face and the face it fits on are perfectly clean when you put them back, because dirt might and probably would throw the part out of line and cause shaft 40P, P. 1, to bind in bushing 42P, P. 1. Also be very sure that screw 201P, P. 2, is set up tight. If it is not it will cause trouble.

INSTRUCTION NO. 52.—End motion in the intermittent sprocket (see General Instruction No. 6) may be removed by loosening the screw in the steel collar between intermittent sprocket 41P, P. 1, and eccentric sleeve 43P, P. 1, and prying lightly against the rim of the sprocket with a screwdriver, letting the point of the screwdriver rest on the collar, which will have the effect of forcing the sprocket to the right and the collar to the left. Tighten up the screw in the collar while it is held in this position.

INSTRUCTION NO. 53.—In threading the projector, when you raise the lower sprocket idler do not jerk it up as though you were working with a two-inch bar. Rough handling of this idler may get it out of line with the sprocket, which will cause the losing of the lower loop. (See General Instruction No. 12).

INSTRUCTION NO. 54.—The quantity of oil in oil well 213P, P. 2, should only be sufficient so you can see the oil splash on the oil window when the machine is running. In order to clean out oil well 213P, P. 2, remove the screw immediately below the glass window, which will allow the oil to drain out, you of course providing something for the oil to run into. Replace the screw, flood the well with kerosene and give the machine a few turns, after which remove the screw, drain out the kerosene and put in fresh oil. (See General Instruction No. 1).

INSTRUCTION NO. 55.—With regard to the idler rollers (see General Instruction No. 12), in order to change the distance of idler rollers from the sprocket, loosen the clamping screw in the hub of bracket, one of which is shown at 800P, P. 1, which will allow of moving the bracket on its shaft. In making this adjustment be very careful not to move the hub of bracket away from the main casting, which would cause the idler to be out of line with the intermittent sprocket.

INSTRUCTION NO. 56.—Upper and lower sprockets may be turned end for end on their shafts in order to present a

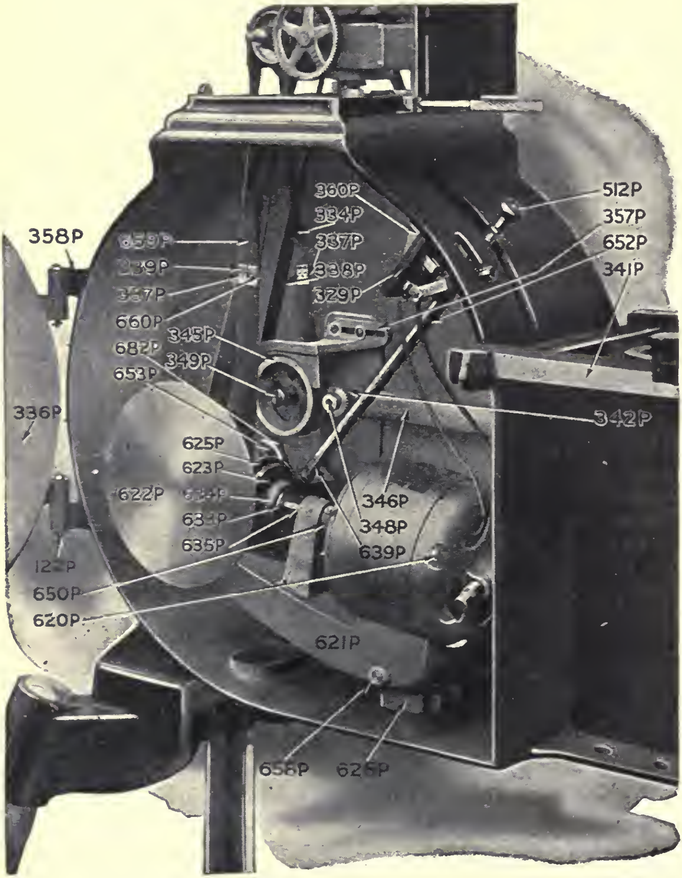


Plate 4, Figure 289.

new tooth surface to the film, if the teeth are worn on one side.

INSTRUCTION NO. 57.—We would by all means advise all purchasers of the Baird projector either at the time of purchase or later on to secure a complete part comprised of 40P, 41P, 51P, 42P and 44P, P. 2. Then when your intermittent sprocket, shaft, bushing or star is worn, all you have to do is to remove the complete part, substitute the new one and send the old one to the factory for inspection and repairs. This is in every way much better than to attempt to put on a new intermittent sprocket. The intermittent sprocket is the heart of a moving picture projector, and it must not only be true down to as little as one-tenthousandth of an inch, but it must be mounted absolutely true also, and the projectionist is seldom in a position to do a delicate job of this kind properly.

INSTRUCTION NO. 58.—The wear of the bushing carrying shaft 170P, P. 1, supporting lower sprocket 452P, P. 1, will have the effect of increasing the distance between the sprocket and its idler. Should you begin to have trouble with losing the lower loop, first see if you can move the outer end of the lower sprocket up and down perceptibly. If you can, the bushing is probably somewhat worn and the distance between sprocket and idler has increased. The remedy is to loosen the idler. (See Instruction No. 55.) When you are making this adjustment hold down on the sprocket; then adjust idler roller to suit this condition.

INSTRUCTION NO. 59.—There should be just sufficient pressure between friction disc wheel 622P, P. 4, and driving friction wheel to cause disc wheel 622P, P. 4, to continue to revolve when belt 659P, P. 4, is slipping on pulley. This pressure is regulated by a knurled nut at the rear end of the shaft, carrying disc-wheel 622P, P. 4. To test the drive, start the motor and grasp the flywheel firmly, causing the belt to slip on the pulley. Any unnecessary pressure between friction disc-wheel 622P, P. 4, and the driving friction wheel will cause excessive wear and loss of power and probably heating of the motor.

INSTRUCTION NO. 60.—At the lower end of rod 639P, P. 4, is a casting supported by a stud attached to the rear wall of the compartment. This casting is supported on the stud by a clamp lined with fibre. Should at any time the knob 512P, P. 4, develop a tendency to work up or down while the motor is running, tighten the screw in this clamp bushing sufficiently to hold the rod in place and prevent the knob from moving through vibration of parts.

INSTRUCTION NO. 61.—On the operating side of the projector at the bottom of the magazine is a horizontal lever, the purpose of which is to raise the discwheel end of part 621P, P. 4, thus releasing belt 659P, P. 4, which operates as follows: When ready to start the show raise the lever up and start your motor by throwing in the handle of switch 329P, P. 4, next set speed regulating knob 512P, P. 4, in running position, if it is not already there. Now when you are ready to project the picture drop the lever slowly down with one hand and as the fire shutter raises raise the dowser with the other hand.

INSTRUCTION NO. 62.—Belt 334P, P. 4, operates the take-up· The take-up gear 342P, P. 4, is on take-up spindle, 348P, P. 4, which carries the lower reed. This spindle is supported by bar 346P, P. 4, which is hinged to the machine casting on the opposite side, just back of the figures 342P, P. 4. The front end of this lever, including the take-up spindle, rests in and is supported by belt 334P, P. 4. The result is that when the reel in the take-up magazine is empty there is very little friction on this belt, but as the film is wound on the reel the weight increases, and thus an automatically regular take-up tension is supplied in excellent form.

INSTRUCTION NO. 63.—Any angle may be given the projector as a whole by loosening the clamps which secure the legs and raising or lowering the projector to secure the desired setting.

INSTRUCTION NO. 64.—The condenser is supported in a metal casing which forms a heat reservoir and will go far toward reducing lens breakage. The casing is so designed that it may be adjusted to suit various conditions. It is advisable that the lens be kept about one-sixteenth of an inch apart.

INSTRUCTION NO. 65.—On the top of the carbon clamp of your lamp, under the clamping screw. is a hole which should be kept filled with powdered graphite at all times. Do this and you will have no trouble with your carbon clamp screws working hard.

INSTRUCTION NO. 66.—The cups on the motor should be kept filled with a good grade of medium oil.

NAMES AND NUMBERS OF PARTS FOR BAIRD PROJECTOR.

Order parts by number only. These numbers are the manufacturers' regular stock numbers. The first column indicates the number of the plate or plates upon which the part appears.

Plate.	No.	Description.
1	— 1P	Bracket for lens and aperture plate.
3	— 2P	Slide for ¼ size lens and shutter guard.
1	— 5P	Aperture plate.
3	— 7P	Spring between lens bracket and slide.
1	— 8P	Frame to hold glass on lens bracket.
3 & 1	— 9P	Screw to adjust lens.
1	— 10P	Knob of lens adjusting screw.
3	— 11P	Glass for lens bracket.
3	— 14P	Pin for film guiding roller.
3	— 16P	Spring for film guiding roller.
3	— 18P	Roller for back edge of film.
1	— 19P	Spreader roller for guiding film.
3	— 20P	Roller for front edge of film.
2	— 25P	Cam shaft.
	— 26P	Fly wheel.
3 & 2	— 27P	Pinion for cam shaft.
	— 28P	Washer for fly wheel.
	— 29P	Screw to hold fly wheel pinion on cam shaft.
3 & 2	— 30P	Bracket for outside bearing on cam shaft—cover for oil well.
3	— 31P	Bushing for outside bearing on cam shaft.
3	— 32P	Gasket for cam shaft bearing.
2	— 33P	Bevel gear on cam shaft.
2	— 34P	Cam.
1 & 2	— 40P	Intermittent shaft.
1	— 41P	Intermittent sprocket.
2 & 1	— 42P	Bushings for intermittent shaft.
1	— 43P	Eccentric sleeve.
2	— 44P	Star wheel.
2	— 45P	Collar on intermittent shaft.
1	— 48P	Bracket for outside bearing on intermittent shaft.
1	— 49P	Screw for bracket on intermittent shaft.
2	— 50P	Pin to adjust eccentric sleeve.
2	— 51P	Gasket for eccentric sleeve.
1	— 52P	Stripper for intermittent sprocket.
1	— 55P	Lower tension shoe.
	— 59P	Spring for lower tension shoe.
1	— 65P	Upper tension shoe.
1	— 66P	Spring for upper tension shoe.
1	— 67P	Adjusting screw for upper tension shoe.
2	— 68P	Adjusting nut for upper tension shoe.
2	— 72P	Screw stop for adjusting nut for upper tension shoe.
1	— 80P	Gate.
	— 81P	Spring for locking pin on gate door.
1	— 84P	Plunger for locking gate door.
	— 85P	Pin for releasing locking plunger on gate door.
1	— 86P	Foot on gate door plunger.
2	— 87P	Knob for releasing pin on gate.
1	— 88P	Rack for fire shutter.
2	— 89P	Pinion for fire shutter.
2	— 90P	Shaft for fire shutter.
	— 91P	Fire shutter.
1 & 2	— 92P	Hinges.
1	— 94P	Spring for edge of film.
3 & 2	—100P	Vertical shaft.
	—101P	Bevel gear on lower end of vertical shaft.
2	—103P	Bevel gear on center of vertical shaft for D. C. projector.
	—104P	Ball bearing for center bevel gear on vertical shaft.
3	—105P	Bevel gear on center of vertical shaft for A. C. projector.
3	—106P	Nut for center bevel gear on vertical shaft.
2	—107P	Driving collar on vertical shaft.
2	—110P	Gear on top end of vertical shaft.
2	—112P	Bushing for top end of vertical shaft.
1	—115P	Lever engaging fire shutter rack.
2	—116P	Shaft carrying levers operating fire shutter.
2	—117P	Lower lever operating fire shutter.
3	—130P	Governor shaft.
	—131P	Pins for governor balls.
	—132P	Pins for collars on governor shaft.
2	—134P	Spring for governor for D. C. projector.
	—135P	Bevel gear on governor shaft for A. C. projector.
2	—136P	Bevel gear on governor shlft for D. C. projector.
3	—137P	Bracket carrying governor shaft.
3	—138P	Ball bearings on governor shaft.

Plate.	No.	Description.
	—139P	Spring for governor for A. C. projector.
2	—140P	Link connecting governor and fire shutter.
2	—141P	Screws to guide governor connecting link.
	—142P	Sleeve on governor shaft.
2	—143P	Fixed collar on governor shaft.
2	—144P	Sliding collar on governor shaft.
2	—145P	Balls for governor.
	—146P	Arm for governor.
3	—150P	Crank handle shaft.
1	—151P	Crank arm.
1	—152P	Screw to hold crank arm.
	—155P	Driving pin in crank handle shaft.
3	—157P	Pulley on crank handle shaft.
3 & 2	—158P	Helical gear on crank handle shaft.
3 & 2	—160P	Oil cup on end of crank handle shaft.
2	—161P	Pulley for motor belt on crank handle shaft.
3	—162P	Collar on crank randle shaft.
2	—163P	Pinion on crank shaft for motor drive.
2	—164P	Bushings for pinions on crank handle shaft.
1	—170P	Lower sprocket shaft.
	—174P	Pinion on lower sprocket shaft.
3 & 2	—176P	Helical gear on lower sprocket shaft.
	—181P	Bracket for carrying lower driving gears.
	—185P	Bushing for gear end of crank handle shaft.
	—186P	Bushing for gear end of lower sprocket shaft.
1	—200P	Sliding main frame.
2	—201P	Screw to lock eccentric sleeve.
	—202P	Bushing for inside bearing on cam shaft.
2	—203P	Bushing for lower end of vertical shaft.
	—205P	Bushing for upper sprocket shaft.
	—206P	Bushing for crank end of crank handle shaft.
	—207P	Bushing for sprocket end of lower sprocket shaft.
2 & 3	—209P	Hook pins for bracket springs.
	—210P	Nut for framing.
	—211P	Plug for cam shaft bearing hole.
2 & 3	—212P	Spring for sprocket brackets.
2	—213P	Glass in front of oil chamber.
	—214P	Glass in top of oil chamber.
2	—215P	Cup for bushing on lower end of vertical shaft.
1	—217P	Spring to support main frame.
	—220P	Post carrying gate door.
3 & 2	—223P	Nuts for top of posts.
	—224P	Nut for bottom of posts.

Plate.	No.	Description.
3	—230P	Post for front end.
1	—236P	Rollers for upper and lower fire valves.
1	—237P	Pins for upper fire valve rollers.
	—249P	Pinion on framing screw.
	—251P	Spring on framing screw.
	—253P	Gear for framing.
2	—254P	Handle for framing.
	—256P	Bracket for fire rollers, front.
	—257P	Pins for lower fire valve.
	—258P	Bracket for fire rollers. rear.
	—259P	Fibre washer for framing screw.
3 & 1	—280P	Bracket carrying roller for upper sprocket.
1	—281P	Rollers for upper and lower sprockets.
2	—282P	Arm for spring on roller bracket shaft.
3	—283P	Nut for sprocket roller shaft.
3	—284P	Sraft for upper and lower sprocket rollers.
	—290P	Bracket carrying rollers for lower sprocket.
1	—292P	Shaft for bracket for lower sprocket.
1	—300P	Bracket carrying rollers for intermittent sprocket.
1	—301P	Shaft for roller for intermittent sprocket.
1	—302P	Shaft for bracket for intermittent sprocket.
1	—303P	Roller for intermittent sprocket.
2	—310P	Shutter for D. C. projector.
	—311P	Hub for shutter.
2 & 3	—312P	Shaft for shutter.
	—313P	Washer clamp for shutter.
1 & 3	—318P	Tube carrying lens.
3	—319P	Casing for ball bearing.
	—320P	Ball bearing.
	—321P	Shutter for A. C. Projector.
4	—329P	Switch for motor.
4	—334P	Belt to drive lower reel.
3	—336P	Door for motor compartment.
4	—337P	Fastener for belt.
4	—338P	Rawhide pin for belt fastener.
4	—339P	Rivet for driving belt.
	—340P	Stationary bracket carrying lamphouse.
4	—341P	Track bars for stationary bracket.
4	—342P	Gear on lower reel shaft for small reel 1¾ core.
4	—345P	Gear and pulley for driving lower reel.
	—346P	Arm carrying lower reel.
4	—348P	Shaft for lower reel.
4	—349P	Pin carrying pulley on lower reel arm.
	—350P	Collar on lower reel shaft.
	—351P	Latch for lower reel shaft.
	—352P	Plunger in lower reel shaft.
	—353P	Spring in lower reel shaft.
	—354P	Pin for latch in lower reel shaft.

Plate.	No.	Description.
4	—357P	Guard for belt on arm carrying lower reel.
3	—358P	Lug for hinge on stand.
4	—360P	Bracket for motor switch.
1 & 3	—450P	Shaft for upper sprocket.
3 & 2	—451P	Gear on upper sprocket shaft.
1	—452P	Upper sprocket and lower.
	—453P	Collar on upper sprocket shaft.
3 & 1	—454P	Shaft for upper sprocket stripper.
3 & 1	—455P	Stripper for upper sprocket and lower.
3	—465P	Main arm carrying stereopticon.
2	—468P	Coupling between stereopticon arm and lens.
2	—469P	Rack for stereopticon arm.
2	—470P	Rod for stereopticon arm.
2 & 3	—471P	Knob for adjusting stereopticon.
2	—472P	Pinion for stereopticon.
3	—473P	Pivot pins for stereopticon rack.
3	—475P	Yoke end for stereopticon.
	—476P	Collar on stereopticon rack.
3	—480P	Housing for stereopticon lens.
3	—481P	Retaining ring for 2⅞" stereopticon lens.
	—482P	Stereopticon lens 2⅞".
4	—621P	Frame for friction drive.
4	—622P	Friction driven disc.
4	—623P	Hub for driving friction wheel.
4	—624P	Arm for moving driving friction wheel.
4	—625P	Face for driving friction wheel.
4	—626P	Pivot base for motor frame.
	—627P	Clamp washer for face of driving friction wheel.
	—628P	Pulley on shaft of driven friction disc.
	—629P	Bushing for driven friction disc shaft.
	—630P	Bushing for ball bearing end of driven friction disc.
	—631P	Bushing for driving shaft on motor drive.
	—632P	Adjusting nut for driven friction disc.
4	—633P	Retaining washer on hub of driving friction wheel.
4	—635P	Shaft for driving friction wheel.
4	—639P	Friction lever for moving friction wheel.
4	—650P	Leather band for flexible coupling.
4	—652P	Rod for speed control.
4	—653P	Ball bearings for friction drive.
4	—659P	Belt for motor drive.
4	—660P	Rawhide pin for driving belt fastener.
2-1-3	—800P	Clamp screws.
2	—822P	Stock screw.
1	—827P	Stock screw.
1	—829P	Stock screw.
	—801P	Clamping screw.
1	—833P	Machine screw, stock.
2	—853P	Stock machine screw.
2	—854P	Stock machine screw.
3 & 2	—867P	Stock machine screw.
2	—868P	Stock machine screw.
2	—872P	Stock machine screw
1	—896P	Sstock machine screws.
1	—906P	Stock machine screw.
2	—866	Stock machine screw
2	— 70	Pin.
3	—801	Nut holding housing 480 to yoke 475.
4	—122	Pin for hinge of door 336.

KNOWLEDGE IS POWER

The Motiograph, No. 1-A 1916 Model

INSTRUCTION NO. 1.—GEAR COVER M-A, 1P, P. 2, carries the parts shown attached thereto in P. 2. By loosening thumb screws 233 (two of them), P. 2, and thumb screw 233, P. 4, the gear cover may be pulled away, together with the parts attached thereto.

INSTRUCTION NO. 2.—Instruction No. 2 omitted.

INSTRUCTION NO. 3.—FRONT PLATE 172, P. 4, which carries the objective lens, may be removed by loosening thumb screws 99A (two of them), P. 4, and raising the outer end of spring 275, P. 4, at the top edge of the front plate, at the same time pulling to top of the plate outward and up.

INSTRUCTION NO. 4.—THE MACHINE GATE is opened by pressing on knob 125P, P. 1. This knob is the end of the gate latch rod, which extends inward and carries gate latch screw 220, P. 1, as may be seen by removing the front plate (see Instruction No. 3) and looking inside the mechanism. Gate latch screw 220, P. 1, is threaded into this knob and may be removed by a screwdriver. Looking inside the mechanism you will see, in the upper left hand corner, a collar on the gate latch rod, held in place by a set screw. This collar serves to compress a small spiral spring. In order to remove this spring, loosen the set screw in the collar and remove screw 220, P. 1, whereupon the gate latch rod may be pulled inward, thus releasing both the collar and spiral spring. Should the gate latch at any time fail to work properly, it is probable that the head of gate latch screw 220, P. 1, has become worn, and a new one should be ordered and installed. It is also possible that the spring has become weak, in which case it should be taken out and either stretched until it gives sufficient compression or a new one may be installed.

INSTRUCTION NO. 5.—TO REMOVE THE MACHINE GATE, unscrew knob 127, P. 1, lift governor rack-bar, 168, P. 2, off standard 83, P. 1, and lift the gate away. In replacing the gate **don't forget to hook the end of the rack bar to standard** 83 P.

CAUTION.—It will probably never be necessary to take the gate apart, and if it is for any reason necessary to do so, we would not advise the projectionist to undertake this particular thing unless he is compelled to. When the gate is once taken apart it is a somewhat difficult matter to reassemble it properly, and we would suggest that instead, should it ever be necessary to make any repairs to its internal mechanism, the gate be sent to the factory. The film tension bars, 96 A, P. 1, and the tension spring can, of course, be removed without taking the gate apart.

INSTRUCTION NO. 6.—APERTURE PLATE 162A, P. 1, may be removed by taking out screws (four of them) 217, P. 1. These screws are small, therefore be careful or you will lose them. Better lay a piece of paper underneath to catch them should they fall, or, better still, handle them with a

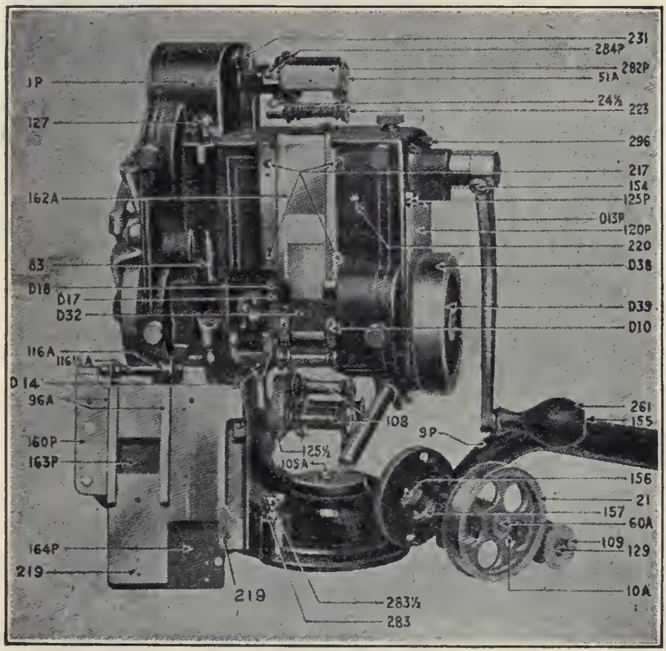


Plate 1, Figure 290.

magnetized screwdriver. (See General Instruction No. 19.)

INSTRUCTION NO. 7. — TENSION SPRINGS AND SHOES.—Tension shoes, 96A, P. 1, are held in place by a one-piece, square, flat spring, 174A, P. 2, which may be seen by looking into the gate edgewise. This spring not only holds the tension shoes in place, but also supplies them with normal tension. The action may be plainly seen by pressing on one of the shoes, at the saime time looking into the gate edgewise. Spring 259P, P. 2, bears on the lower edge of spring 174A, P. 2, and by means of thumb screw 245, P. 2, may be caused to supply auxiliary or increased tension to the bottom of the tension shoes. Tension shoes, 96A, P. 1, may be removed as follows: Loosen screws 294 and 222, P. 2, and swing cooling plate over to the left out of the way. Next block

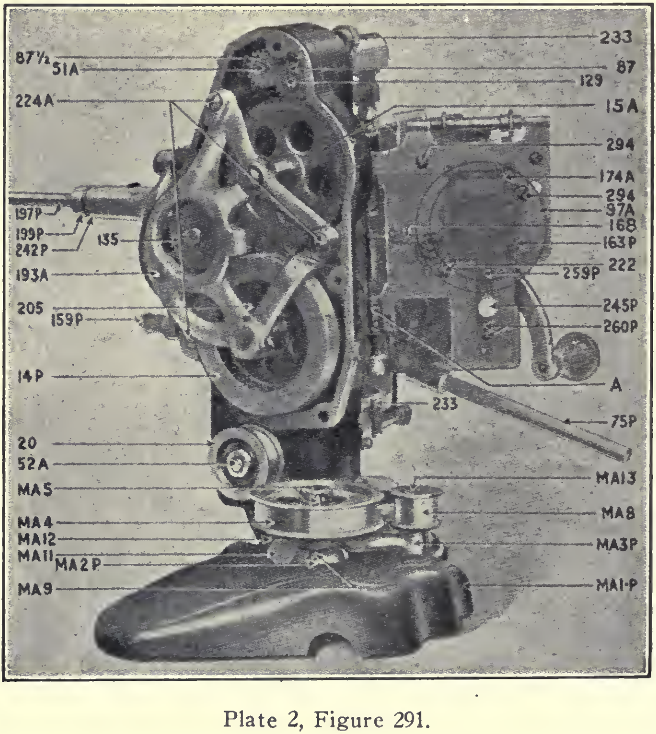


Plate 2, Figure 291.

fire shutter, 163, P. 2, up out of the way. You will then see spring 174A, which is held by two round-head screws, one at either side of the aperture. First, having backed off on thumb screw 245, P. 2, until spring 259, P. 2, is out of contact with spring 174A, remove the two screws holding spring 174A, and pressing in on the tension shoes with the thumb and finger of one hand and in on the top and bottom of spring 174A, P. 2, with the thumb and finger of the other hand, slip spring 174A down slightly, which will unhook it from the tension shoes and release both them and the spring.

In replacing the shoes and spring, place the shoes in proper position so that the hooks on the lugs will point downward, and pressing spring 174A down flat, slip it up under the hooks until they are engaged, whereupon replace the screws and swing the cooling plate back in place, tighten up its holding screws and the job is done.

INSTRUCTION NO. 8.—AUTOMATIC FIRE SHUTTER BLADE, 163P, P. 2, may be removed as follows: First follow Instruction No. 5; next remove screws 219, P. 1, and another similar screw about three inches immediately above. Loosen screw, 294, P. 2, and you can lift the entire front plate of the gate away, which will release automatic fire shutter, 163P, P. 2.

INSTRUCTION NO. 9.—Tension Spring, 259, P. 2, may be removed by following Instruction No. 8, and then taking out screws, 260P, P. 2.

INSTRUCTION NO. 10—TENSION.—(See General Instruction No. 9). The tension may be increased in two ways, first by removing spring, 174 A, P. 2 (see Instruction No. 7), and bending it in proper direction to supply added tension, or by tightening up on thumbscrew, 245 P, P. 2. It is intended that spring 174 A, P. 2, shall supply proper tension without help from spring 259, P. 2.

INSTRUCTION NO. 11.—To REMOVE UPPER SPROCKET SHIELD, 282 P, P. 1, remove screws (two of them) 284 P, P. 1.

INSTRUCTION NO. 12.—TO REMOVE UPPER SPROCKET, 106, P. 4, remove the set screw in the center of its hub, and pull the sprocket off the shaft. In replacing it remember that the end having an offset hub goes in toward the casting. If put on the other way the sprocket will be out of line with the aperture, and there will be trouble. Having removed the hub you can pull its spindle 51 A, P. 1

and 2, carrying gear 87½, P. 2, out to the left, first having removed the gear cover. (See Instruction No. 1.)

CAUTION.—In removing upper and lower sprockets you must take the set screw clear out before you can pull the sprocket off.

INSTRUCTION NO. 13.—TO REMOVE UPPER

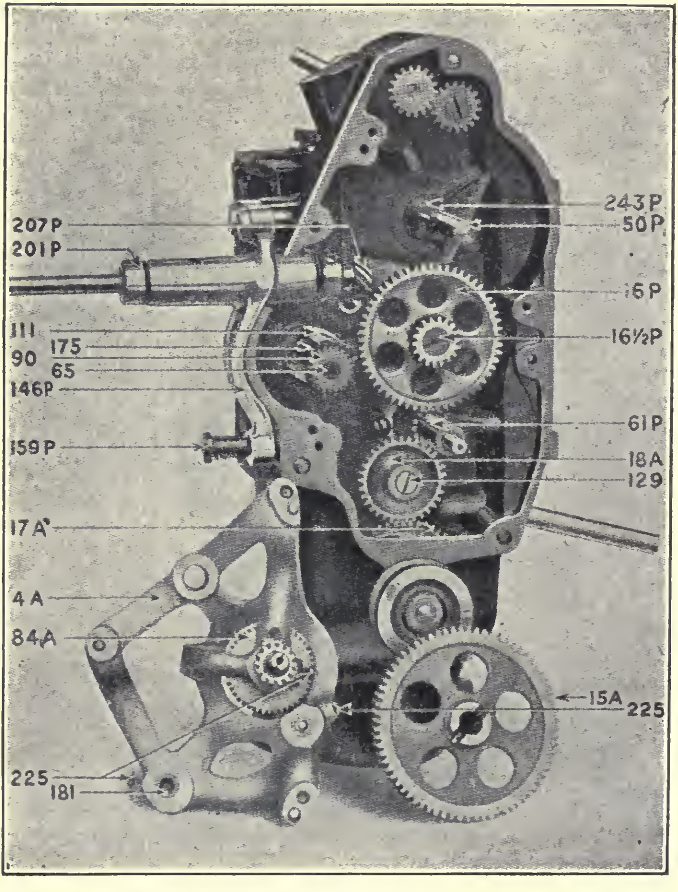


Plate 3, Figure 292.

SPROCKET IDLER BRACKET, 24, P. 4, remove set screw 249, P. 4, loosening screws 227 and 265, P. 4. Next remove top sprocket, 106, P. 4 (see Instruction No. 12), and you can pull the bracket away.

INSTRUCTION NO. 13½.—IDLER ROLLER, 108, P. 4, is held away from the sprocket (see General Instruction No. 12) by screw 241, P. 4, which is locked by knurled knob, 241, P. 4. Idler roller, 108, may be removed from its spindle by taking out screw 223, P. 1. We would advise the projectionist to remov the upper, lower and the intermittent idler rollers at least once each week, clean and lubricate their spindles, using a medium light oil for the purpose. True, there is an oil hole in their center, but better take them off.

INSTRUCTION NO. 14.—LOWER SPROCKET, 106, P. 4, may be removed by taking out the screw in its hub and pulling the sprocket off the shaft, first having raised the idler bracket. If it is desired to remove its spindle, 52 A, P. 2, which carries take-up belt driving pulley, 20, P. 2, it will first be necessary to follow Instruction No. 23. Having done so you will see, down in a pocket inside the frame casting, gear 17 A, P. 3, which drives the lower sprocket shaft. Loosen the set screw in its hub, backing it off a considerable distance, as it is deeply countersunk into the shaft, and you can pull the driving pulley and spindle out to the left. In replacing same be sure you get set screw which holds gear 17 A, P. 3, properly located in the countersink in the shaft, and **set it up tight,** because if this set screw works loose it will be a job to get at it and retighten.

INSTRUCTION NO. 15.—LOWER SPROCKET IDLER BRACKET, 25 A, P. 4, may be removed by loosening the screw in the upper end of spring 274, P. 4, and screw 249, P. 4, and screw 227, P. 4. In replacing same be sure to tighten up screw 227, P. 4, and the one on top of spring 274, and to readjust screw 249, P. 4, so that the spring has the proper tension. Lower idler roller, 108 A, P. 4, is merely a guide roller and sets approximately one-eighth of an inch from the sprocket. The other two rollers should, however, be adjusted by means of screw 241¾ and lock nut 241, P. 4, as per General Instruction No. 12. Any of these idler rollers may be removed from their spindle by taking out the screw in the end thereof, but it will be necessary to take off the entire bracket in order to get the center roller off.

INSTRUCTION NO. 16.—GEAR BRIDGE, 4 A, P. 3, may be removed by taking out screws 224 A (three of them), P.

2. Back these screws out for about one-half inch and then, using a screwdriver, carefully pry the bridge away. The holding screws are "necked," in order that they may be left in the bridge to avoid the possibility of becoming lost. When you have backed them off for about one-quarter inch they will release the main casting, though they are still attached to the bridge. In replacing the bridge be sure that you get the end of the spindle carrying gear 84, P. 3, properly entered in its bearing and also that shaft 50 D, fly wheel shaft 61 P, and the pin entering spindle 65, all P. 3, are properly entered, and that the locating pins enter their proper receptacles. **Do not attempt to drive the bridge on.** If you start it right it will enter without any trouble, and all that will, in any event, be necessary, will be to tap the casting lightly with the handle of the screwdriver immediately over each of the two locating pins.

INSTRUCTION NO. 17.—TO REMOVE REVOLVING SHUTTER SHAFT, 197 P., P. 2, remove screws 159, P. 3, and 158 P, P. 4. You may then pull the spindle and its casting, together with the revolving shutter and gear 207 P, P. 3, out. Having done this, if it is desired to remove the shutter spindle from the casting, you may do so by loosening the set screw in collar, 201 P, P. 3, which will allow you to pull the spindle out of the casting.

CAUTION.—At either end of the shutter spindle bearing is a fibre washer. Be sure and get these washers back in place in reassembling.

INSTRUCTION NO. 18.—TO REMOVE FLY WHEEL 14 P, P. 2, follow Instruction No. 16, after which remove the two set screws in the hub of the fly wheel. It is better to remove these screws, as they are deeply countersunk into the shaft, then grasping the fly wheel on the other end of the shaft to hold it stationary, twist fly wheel 14 P, P. 2, at the same time pulling outward, and thus working it off the shaft.

CAUTION.—In replacing be sure to get the screws properly located in their countersink.

INSTRUCTION NO. 19.—TO REMOVE GEAR 87, P. 2, take out set screw 129, P. 2, which releases the gear.

INSTRUCTION NO. 20.—TO REMOVE GEAR 15 A, P. 2, follow Instructions Nos. 16 and 17, whereupon the gear may be pulled off the spindle.

INSTRUCTION NO. 21.—TO REMOVE CRANK SHAFT 50 P, P. 3, first detach the crank, O 13 P, P. 1, then follow Instruction 20, thus releasing the shaft, which may be pulled out from the left hand or gear side.

INSTRUCTION NO. 22.—TO REMOVE GEAR 16 P, P. 3, follow Instructions Nos. 16, 17, 18 and 20, in their order, and then take out screw 16½ P, P. 3. This releases the gear. In replacing be sure that you set up screw 16½ P, P. 3, tight.

INSTRUCTION NO. 23.—TO REMOVE GEAR 18 A, P. 3, follow Instructions Nos. 1, 16 and 18, and then remove screw 129, P. 3. In replacing be sure to set screw 129 up tight.

INSTRUCTION NO. 24.—TO REMOVE GEAR 17 A, P. 3, follow Instructions Nos. 1, 16, 18 and 23, and then loosen the set screw in the hub of gear 17 A, P. 3. Next loosen the set screw in the face of belt pulley 20, P. 2, and slip the pulley

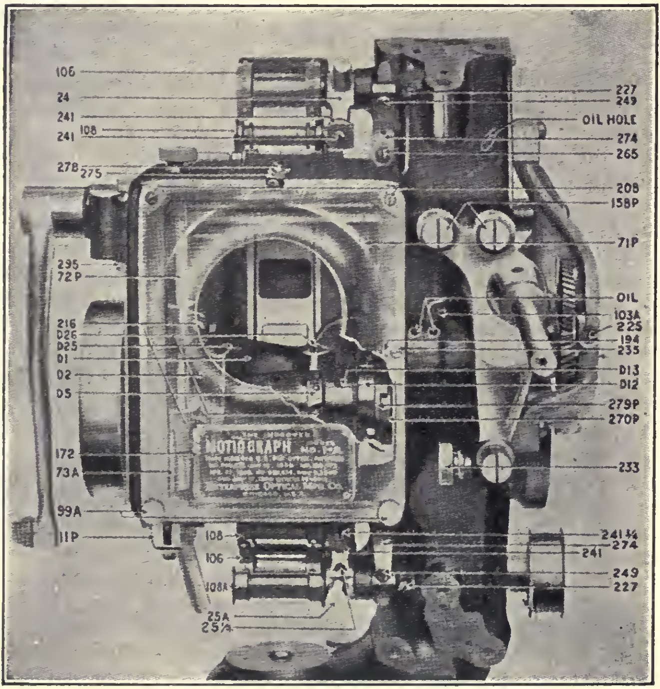


Plate 4, Figure 293

off its shaft. You may then pull spindle 52 A, P. 2, out from the sprocket side thus releasing the gear.

INSTRUCTION NO. 25.—TO REMOVE AUTOMATIC GOVERNOR SHAFT 65, P. 3, and the parts attached thereto, follow Instructions Nos. 1, 16 and 18; then, looking in past the left-hand edge of the fly wheel, you will see a set screw in the hub of a casting in the end of standard 83, P. 1. Loosen this set screw until the casting will revolve on the rod, whereupon you can pull the whole governor away. Should it ever become necessary to renew the springs, gear, or other parts of the governor, we would advise that it be sent to the factory by insured parcel post. **Don't try to do this particular job yourself.** In replacing the governor the set screw in the casting is countersunk deeply into the shaft, and it is necessary that this screw enter the countersink, else standard 83, P. 1, will not set right, and your automatic fire shutter will not work.

INSTRUCTION NO. 26.—FRAMING CARRIAGE D 1, P. 4, carrying outside fly wheel, D-38, P. 1, may be removed as follows: First loosen screws 216 (two of them), P. 4, and then, by means of knurled knob at its top, unscrew framing carriage guide rod 72 P, P. 4, and pull it out. Next remove the screw which holds the upper end of the link which joins the framing carriage and framing lever casting 11 P, P. 4. Next loosen the two screws, one at each lower corner of the nickel plated shield in the side of the mechanism back of the fly wheel, and raise knob 296, P. 1. You may then, by working it around a little, pull the whole framing carriage out to the right—on the crank side of the mechanism.

INSTRUCTION NO. 27.—TO REMOVE FLY WHEEL SHAFT 61 P, P. 3, follow Instructions Nos. 1, 16, 18 and 26, then loosen a set screw in the face of the framing casting just behind the lower gate hinge. You will be obliged to remove the gate in order to get at this set screw. (See Instruction No. 5.) This set screw holds the bronze bearing in which the shaft runs, and you may then, using either a copper or a hard wood punch, drive the shaft bearing and inner end of the toggle out into the interior of the frame casting.

INSTRUCTION NO. 28.—STRIPER PLATE D 32, P. 1, (F-F, P. 5), may be removed by taking out the three screws at its lower end. (See P. 5.)

INSTRUCTION NO. 29.—FLY WHEEL, D 38, P. 1, may be removed by taking out the two set screws in its hub. They are deeply countersunk, and must be backed out for quite a distance before the wheel will be released. When the wheel is released from the screws, hold the fly wheel on the opposite end stationary while you pull the wheel off with a twisting motion.

INSTRUCTION NO. 30.—TO OPEN THE OIL WELL follow Instruction No. 29, and then loosen the screw at each lower corner of the nickel plated shield behind the fly wheel and remove it; next remove four machine screws in the black casting on the end of the framing carriage. These screws hold the cover of well E, P. 5, and having removed them you can pull the cover off, tapping it lightly to break the joint. Before starting this job, you can, if you wish, remove the whole framing carriage from the mechanism. See Instruction No. 26. It is well to remove the oil well cover, say once in each five or six hundred hours running, and clean it out thoroughly.

Never use graphite in the oil well unless you want trouble, and plenty of it.

CAUTION.—In replacing the oil well cover be sure that you wipe both the surfaces perfectly clean. If you do not there is apt to be a leakage of oil.

NOTE.—Directions follow for the removal and renewal of cam, star and intermittent sprocket and their bushings. We do not, however, advise this. It is much better to purchase an extra framing carriage, and when anything goes wrong with the old one, or when excessive wear develops in the bushings, spindles, intermittent sprocket, or other parts, insert the new carriage in the machine and send the old one to the factory by parcel post for repairs. It is, of course, possible that the projectionist can and will make the necessary repairs in an entirely satisfactory manner. Still, when one considers the delicacy of the parts and the fine adjustment necessary, one readily sees that this can be best done at the factory, where all necessary tools and men skilled in this class of work are available.

INSTRUCTION NO. 31.—CAM SHAFT X, P. 5, carrying cam G, P. 5, may be removed by following Instruction No. 30, and then loosening the set screws D 13 (two of them) in part D 12, P. 4. Back these screws out a considerable distance, as they are deeply countersunk in to the shaft. Having done so you can pull the cam and shaft away, which releases part D 12, P. 4.

INSTRUCTION NO. 32.—THE STAR AND ITS SHAFT J, P. 5, may be removed by following Instructions Nos. 26, 28, and 31. Having done so, take out the two set screws in the hub of intermittent sprocket D 10, P. 1, and you can pull the star and shaft out.

INSTRUCTION NO. 33.—TO REMOVE THE BEARINGS of the Intermittent sprocket Shaft follow Instruction No. 32. The bearing on the star end is held by a set screw, the head of which is in the top of the casting, and the bearing in the other end is held by a set screw in the face of the casting at

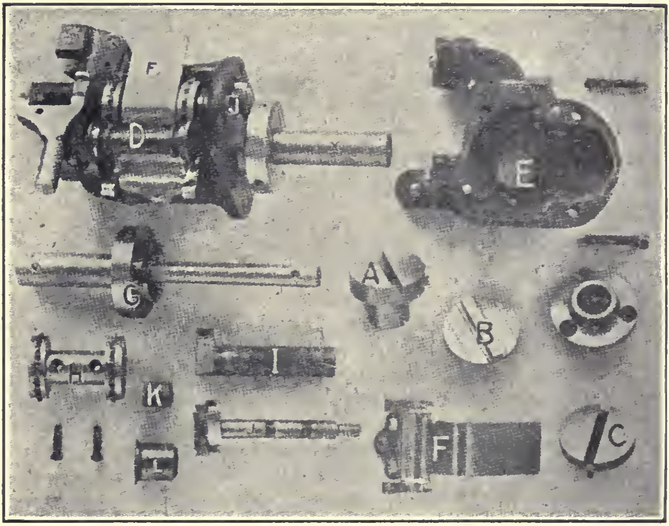


Plate 5, Figure 294.

the end of the bearing. Remove these screws and you can drive the bearing out and insert new ones. The screws in the face of the casting which holds the left hand bearing should be set up just far enough so there is no end motion in the intermittent sprocket. If you set it tight you will bind the sprocket; if you leave it too loose the sprocket is apt to have end play.

INSTRUCTION NO. 34.—THE BEARINGS OF THE CAM SHAFT may be removed by following Instructions No. 26 and

31. This bearing extends the full length of the casting. It is held at one end by a set screw, the head of which is in the top of the framing carriage casting; the other end is held by two set screws which bear against the lug in the end of the bearing. This bearing is eccentric. Having loosened the two set screws which bear against the lug, and the one in the top of the casting which holds its other end, you may drive the bearing out, using a hard wood punch. In replacing it it will be necessary to adjust the bearing carefully. Proceed under Instruction No. 35.

INSTRUCTION NO. 35.—ADJUSTING INTERMITTENT MOVEMENT.—When the intermittent sprocket develops considerable circumferential play, or the intermittent movement becomes noisy it is in need of adjustment. Proceed as follows. Set screws D 26, P. 4, (two of them), bear against eccentric bearing lug D 5, P. 4, and a movement of these set screws has the effect of altering relation of the star and cam to each other. When you loosen the lower screw and tighten down on the upper one you tighten the cam against the star, thus eliminating the lost motion in the intermittent sprocket, but you must be very careful and not get the movement too tight or you will have trouble, particularly if the adjustment be done while the machine is cold. Tighten up on the upper screw, first having backed off on the lower one, until you can feel just the least bit of shake in the intermittent sprocket when you try it with your finger. Having got your adjustment made tighten up both set screws. This adjustment must be made with the movement "on the lock"—in position when the sprocket is locked.

INSTRUCTION NO. 36.—ADJUSTING THE FRAMING CARRIAGE.—The ease with which the framing carriage moves up and down is governed by screws 216 (two of them), P. 4. Tightening these screws has the effect of pressing together the casting lug on the guide rod, thus making the carriage move harder; conversely loosening these screws makes it move more easily.

INSTRUCTION NO. 37—BEARINGS.—All bearings of the Motiograph machine are held by set screws, and may easily be removed for replacement. Bearing 194, P. 4, is held by set screw 235, P. 4. The bearing which can be seen just at the bottom of gear 207 P. P. 3, is held by set screw 103 A, P. 4. The bearings in bridge 4 A, P. 3, are held by set screws 225 (three of them), P. 3.

INSTRUCTION NO. 38—OIL.—**Never under any circumstances use graphite in the oil well.** Graphite is ordinarily one of the finest lubricants made, but it does not work at all satisfactorily in the intermittent movement of a projector, nor do we advise its use on gears or on any part of the mechanism. We would advise the use of a very heavy oil, such as Mobile B, which can be had at almost any garage, for the toggle joint. This joint works, under considerable pressure, at high speed. If a light oil be used it is likely to be thrown off rapidly. Mobile B ought to be about right.

INSTRUCTION NO. 39—LINING THE SPROCKETS.—See General Instruction No. 4.

INSTRUCTION NO. 40—KEEPING THE SPROCKETS CLEAN.—See General Instruction No. 3.

INSTRUCTION NO. 41.—SETTING THE SHUTTER.—See General Instruction No. 22.

INSTRUCTION NO. 42.—SPROCKET TEETH.—See General Instruction No. 7.

INSTRUCTION NO. 43.—MOTIOGRAPH TAKE-UP uses a flat belt about one-half inch wide. This belt is driven by pulley 20, P. 2, the driven pulley being shown, not attached to the mechanism, at 10 A, P. 1. The belt is given the necessary tension by idler pulley 109, P. 1, the tension being governed by set screw 156, P. 1. This plan is quite efficient, but the projectionist should see to it that the adjustment of idler 109, P. 1, is carefully made, else there will be a heavy pull on the film, which is, of course, injurious.

Speed Indicators

WE have for more than twelve years insisted that there is only one proper method of gauging the speed of projection, viz.: by watching the screen and so regulating the speed of the projector that there will be absolute naturalness of action in all moving things in the picture. **We still insist that this is the fact,** but until such time as either some method be evolved for automatically synchronizing camera speed and projection speed, or projectionists themselves are able and willing to concentrate on their work that knowledge and extremely close attention necessary to the production of naturalness of action, and theatre managers cease compelling the projectionist to run to fixed schedule regardless of the time required for proper projection, it is desirable that some device be installed in the projection room by means of which the exact speed of projection may be constantly under the eye of the projectionist.

In any event, however, a projection speed indicator is desirable if it be rightly used, but **the right way of using it is to either first project the picture and record the correct speed for each individual scene, and thus make a projection cue sheet, or for the producer himself to send a cue sheet indicating the proper speed of projection for each scene.**

POSSIBLE ABUSES.—The trouble with speed indicators is that in present procedure they are often utilized to produce what amounts to an outrage on projection, because often the power is placed in the hands of an orchestra leader to compel the emasculation, or even the absolute butchery of artistic work on the screen in order that the music and the picture may synchronize without disturbing the tempo of the music. Also the theatre manager all too often, without knowing a thing about the speed of projection necessary to artistic work in any individual scene, arbitrarily compels a speed of projection to accommodate a schedule which may be totally unfitted to artistic screen results. **The fact that a speed indicator is located in his office enables him to compel his projectionist to commit an outrage on the production he is placing before the audience, and on his own profession as well.**

We cannot, however, ignore a device which has merit, simply because that device is abused, or may be abused, therefore we are including a description of speed indicators.

POWER'S SPEED INDICATOR.—The Nicholas Power Company has what seems to be a very excellent speed indicator, which may be ordered as special equipment for the Power's Projector.

This indicator is illustrated in Fig. 294. As will be noticed, the upper score indicates the rate of speed per minute at which the film is being projected, and the lower score the number of minutes required to project a thousand feet of film. Examining the two scores, you will see that at 100 feet a minute it takes 10 minutes to project 1,000 feet of film, and at 40 feet a minute it takes 25 minutes to project 1,000 feet of film.

In Fig. 295 the various parts of the Indicator are shown. With it is supplied a table, A, Figs. 294 and 295, which is attached to the projector frame just back of the lower fire

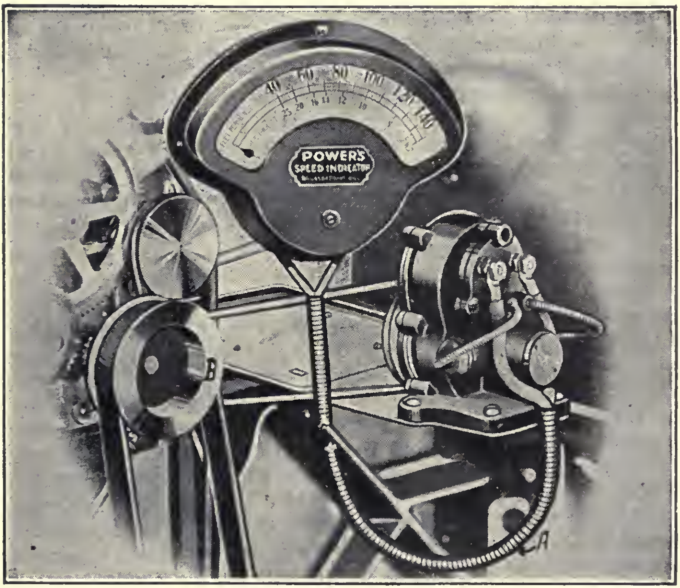


Figure 294.

shield. This table has an extension, B, Fig. 295, which holds the indicator mechanism as per Fig. 294. The indicator head is connected to the mechanism by means of an electric circuit carried in a conduit, A, Fig. 294. The indicator head may be located at any desired place, but it should be beside the observation port. There may be a multiplicity of connecting circuits, so that one mechanism may be used to operate indicator heads in the projection room, in the orchestra pit and in the manager's office if so desired. The driving power is taken from pulley B, Fig. 294, C, Fig. 295, which is a special pulley provided with the outfit. You have only to slip off the regular projector driving pulley and put on the special one, C, Fig. 295. The apparatus is simple, well constructed, and will deliver the goods.

POWER'S COMBINATION PANEL.—In Fig. 296 we have a view of a combination panel put out by the Nicholas Power Company. This panel is 10 inches high and 18 inches wide. From wall to face it is 4 inches at the top and 7 at the bottom, which gives good display to the speed indicator (head) the voltmeter and ammeter mounted thereon.

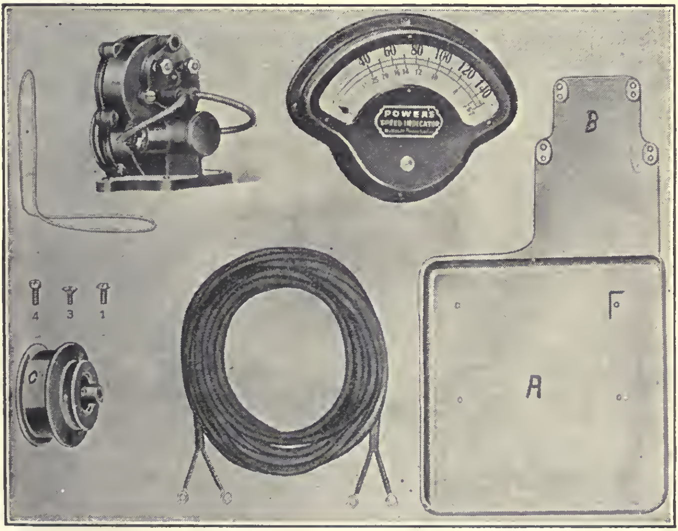


Figure 295.

Speed indicators for orchestra pit and manager's office may also be connected to the panel.

The voltmeter is of the low voltage type, the maximum being 75 volts. Inside the panel is an automatic relay which automatically disconnects the instrument from the circuit when the arc lamp is not in use, thus protecting the same from injury by line voltage, even though the projector table switch is in.

An ammeter of any desired capacity can be supplied, and shunt for same may be mounted inside the panel, or at any desired point on the circuit. When it is located at some distant point, as for instance on the back of generator panel,

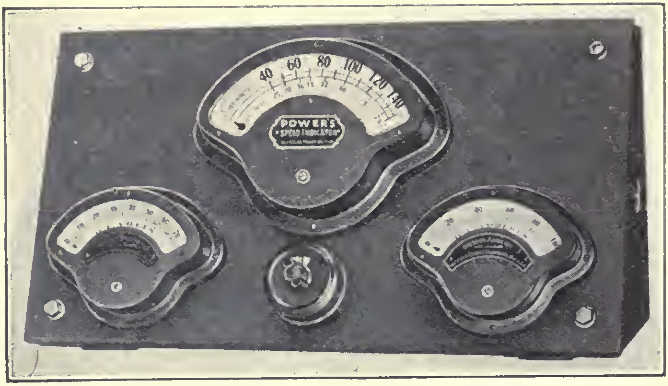


Figure 296.

it is only necessary to run a circuit of No. 14 wires from the shunt to the ammeter.

On the panel is mounted a control switch, the function of which is to connect the speed indicator generators to the speed indicator units on the panel, so that each projector generator is in turn disconnected when the projector is shut down, and the generator of the next placed in operation is connected by a turn of the switch. The instruments are high grade Weston instruments.

HALLBERG SPEED INDICATOR.—The Hallberg indicator parts are shown in Fig. 297. It is essentially an electric device. A small generator of special characteristics is mounted on a bracket attached to the projector. The generator is driven by a pulley attached to the projector mechanism. The current from the generator is supplied to a distribution box located on the projection room panel, or switch board, whence it reaches and operates an indicating meter in the projection room, one in the orchestra pit and one in the manager's office, if it be so desired.

Fig. 298 shows the dial of the recorder. On the wall, near the lower left-hand corner of Fig. 297, is a recording instrument by means of which a permanent record of speed of projection is inscribed on a paper dial. This is a valuable feat-

Figure 297.

ure of the device in that it makes arguments and disputes as to the speed at which any production, or any scene of a production was projected impossible. The Hallberg speed indicator is a well designed, well-made piece of apparatus. It is deserving of consideration by those who propose installing such a device.

ROBBIN SPEED INDICATOR.—There is a speed indicator made by Mr. Robbin, New York City. This manufacturer was invited, on several occasions, to submit his ap-

Figure 298.

paratus for description in this book, or to himself prepare matter, subject to our own revision and editing, but he has failed to do either of these things, which we believe it will be agreed does not evidence very great consideration for the many thousands of users of this book, many of whom look to it for instruction and guidance in matters pertaining to projection room practice and, to a greater or less extent, in projection apparatus.

Mr. Robbin's speed indicator we understand to be an excellent piece of apparatus of its kind.

The High Intensity Arc

THE high intensity arc has several advantages as against the ordinary electric arc for projection purposes. Chief of these advantages are: (A) the crater faces the collector lens squarely, as shown in Figs. 299, 300 and 302. This is an advantage because whereas the most efficient angle at which the ordinary arc crater could be set to the lens (an angle of 55 degrees from the optical axis of the lens system) directs the strongest light flux toward the lower half of the collector lens, instead of its center, the high intensity crater directs its strongest light straight toward center of collector lens.

(B) The intrinsic brilliancy of the high intensity arc crater per unit of area is very much higher than is that of the ordinary arc crater. The brilliancy of the ordinary arc crater when operating with cored carbons is given by Blondel as 132 c. p. per square m. m., but by reason of modern improvement in projection carbons this is claimed to be increased to about 160 c. p.

The high intensity men claim a brilliancy of 500 c. p. per square m. m. for their product. We have not as yet verified this claim, but certainly the high intensity arc crater has a very much higher brilliancy per unit area than has the crater of the ordinary arc. That statement is not a subject for questioning.

(C) The crater area per ampere is decidedly less than that of the ordinary arc. By this we mean that a 75-ampere high intensity crater, for instance, will have very much less diameter and area than will a 75-ampere ordinary arc crater. Exactly how great an advantage this is we are not prepared to say, but certainly it is an advantage because it seems quite possible to secure all the screen brilliancy any reasonable man could want without encountering the inefficiency under which the ordinary projection arc labors when working at high amperage. See Pages 396 to 398.

The point of highest efficiency of the ordinary D C arc is about 60 amperes. We believe there would be no appreciable loss in efficiency with the high intensity arc until the 100 ampere, or possibly 120 ampere, point was passed.

We recommend the high intensity arc to exhibitors and projectionists who desire high screen brilliancy

COLOR OF LIGHT.—Screens illuminated by the high intensity arc are very brilliant, but the light tone is not, at this time (1922) as warm in tone as is the light from the ordinary arc. Notwithstanding this phase of the matter, which may be corrected later, the public seems to like the high intensity screen illumination. We have not heard a single theatre patron criticize it adversely, but have heard many express approval of the brilliancy of the light.

THE GENERAL ELECTRIC LAMP.—The General Electric Company and the Nicholas Power Company, working in conjunction, have developed a high intensity lamp, illustrated in Figs. 299 and 300, which same is being put out as special equipment by the Nicholas Power Company. Fig. 299 shows right-hand and Fig. 300, left-hand side of the lamp.

In general the operation of the lamp is as follows: The carbons, both positive and negative, are fed by a small motor located under the base of the lamp. The motor armature and field are connected across the arc, which has the effect of

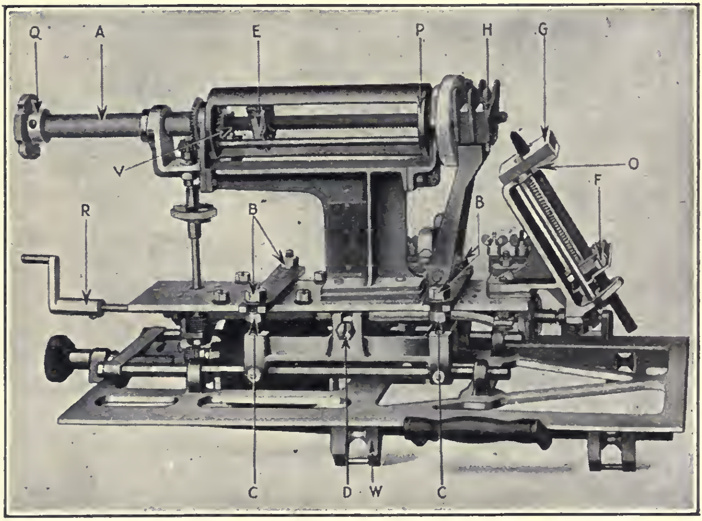


Figure 299.

increasing the speed of the motor when the arc length is increased and the arc voltage, therefore, increased; or slowing down the motor when the arc gets shorter. This is precisely the principle upon which some of the oldest and best arc controllers operate and its application to this lamp should maintain the arc automatically with but very little attention. Knob Q and crank R, Fig. 299, are for the purpose of feeding the carbons by hand, when, or if, necessary.

The positive carbon is pushed through an opening in tube A, Fig. 299, and shoved through clamp E and positive contact shoes H, until its tip extends 9/16 of an inch as per Fig. 301.

The carbon is held by clamp E, Figs. 299 and 300, which clamp engages with feed screw M, Fig. 300. Positive carbon clamp E is insulated so that no current can enter the carbon through the clamp. This prevents the carbon heating by having current forced through its entire length, it also prevents positive feed screw M and negative feed screw L, Fig. 300, from carrying current which might cause disastrous arcing between the clamp and feed screw.

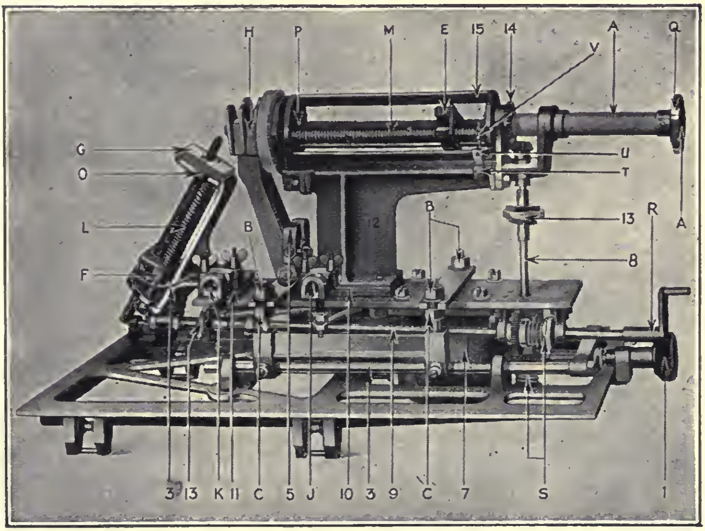


Figure 300.

CURRENT ENTERS THE CARBON.—Current is conducted to the positive carbon through the floating contact shoes, shown at H, Figs. 299 and 300. These contact shoes are held in contact with the carbon by the action of a coil spring and are so arranged that they may make a firm and even contact with the carbon at all times.

The current enters the negative carbon through carbon clamp F, Figs. 299 and 300. Current is supplied to this clamp through flexible wire jumper, shown at 3, Fig. 300. The negative carbon is a metal coated carbon and the current is conducted from the clamp through the full length of the carbon. Both the negative clamp F and the positive carbon clamp H are insulated from the body of the lamp. This is illustrated in Fig. 302, the dotted line representing the path followed by the current through the lamp.

POSITIVE CARBON ROTATED.—From Q to P, Figs. 299 and 300, the parts form one assembly. Looking at Fig. 300, between the arrowheads 14 and 15, you will see directly in front of gear to which arrow 14 is pointing, a casting which forms one end of the support for the positive carbon carriage. The other end of this carriage is supported by a similar casting between arrows H and P, directly behind positive contact shoes H and asbestos baffle plate. This carriage, including part A and Knob Q, is continuously rotated by the motor, carrying with it, of course the positive carbon, as well as feed screw M and clamp E, both of which are mounted on the carriage. The rotation of the positive carbon maintains at all times a perfectly round and symmetrical positive crater.

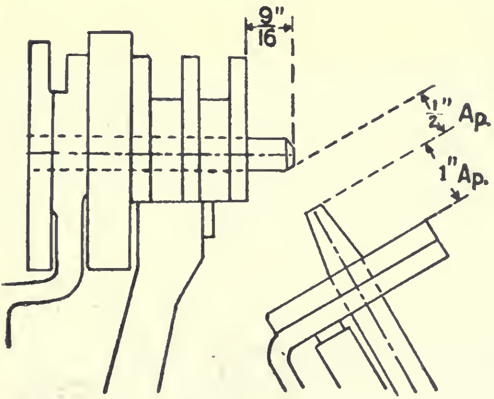


Figure 301.

The positive carbon is not fed continuously, but intermittently. This is accomplished as follows: On the rear end of positive feed screw M, a ratchet wheel is mounted, indicated by V, Fig. 300. On the stationary frame of the lamp, U, Fig. 300, is a spring pawl and every time the positive carbon carriage rotates, this pawl engages the ratchet and pulls it and the positive feed screw around slightly.

Adjustment screw T, Fig. 300, is provided to enable the projectionist to regulate the rate of feed of positive carbon.

SAFETY CLUTCHES.—The motor is directly connected, through gearing, to the feeding mechanism and there is provided, both as a safety device and to enable the projectionist to feed the carbons by hand without disconnecting the motor, a spring pressure friction clutch, which is placed on both the positive and negative feed rods. They are indicated at S, Fig. 300. The gear at the front end of the clutch is not connected to the shaft but rotates loosely thereon. It is held, or gripped, between two collars, one of which, the one between the support bearing and the gear, is attached to the feed shaft and must rotate therewith. The pressure is applied by a coil spring which rests against the collar which rotates loosely with the gear. This pressure can be adjusted by tightening or loosening the hexagon lock nut on which arrowhead S is resting. By examining this construction, you will see that if crank R is turned with sufficient force, the feed rod will be rotated although the gear must remain stationary or may be running with the motor. When crank R is rotated, the friction supplied to the clutch by the coil spring is overcome and the carbons are thus fed by hand, regardless of whether or not the motor is running.

These clutches act as safety devices as follows: If either the positive or negative carbon be burned too short, the positive clamp E will strike the front of the carriage at P, Fig. 300, or negative clamp F will strike the negative head at O, Fig. 299. When this happens the feed screw could feed the clamp and carbon no further and the motor would instantly be stalled with probable serious injury to its armature. In that event, however, the clutches operate and allow the motor to continue running although under heavy load.

HAND FEEDS WORK HARD.—For the reason that in order to operate the hand feeds the clutches must be slipped, these feeds work hard.

NOTE.—The pressure of the springs operating the clutches must be sufficient to enable the motor to drive the feeding mechanism, but not so great that the feeding mechanism will work unnecessarily hard, or that the motor will be stalled if one of the clamps strikes, as before described.

THE NEGATIVE CARBON is fed upward by feed screw L, acting through carbon clamp F. The feeding is not intermittent but continuous. The negative is not rotated. It may be fed by hand by means of crank R, Figs. 299 and 300.

INSTALLATION.—The lamp is installed in the lamphouse by the manufacturer, the lamp and lamphouse not being sold separately for an original installation. It is so adjusted by the manufacturer that the center of the positive carbon is exactly on the optical axis of the lens system. It is, however, possible that the adjustment may be altered in shipment, or it may be that you will have occasion to order a new high intensity lamp to install in place of an old one.

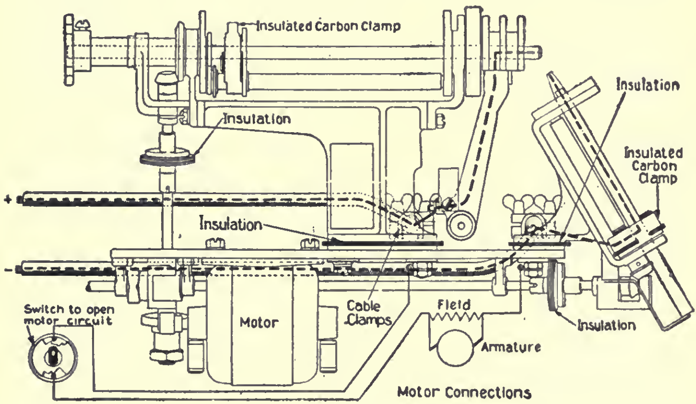


Figure 302.

On receipt of a new high intensity outfit, or when you install a new lamp in the place of an old one, you should set the alignment of the lamp, as follows: Secure a perfectly straight rod of steel or iron having the same diameter as the positive carbon (11 m.m. or about 7/16 of an inch) and long enough to reach from an inch or more back of knob Q to the front of the projection lens tube. Test the rod for straightness by rolling it on a perfectly flat surface. Remove the condenser lenses, open the projector mechanism gate, and take out both combinations of the projection lens, placing the empty lens barrel back in place in the holder. Remove the positive carbon and shove the iron rod through tube A, clamp E, positive contact shoes H and on through the aperture and lens barrel. If the rod is exactly central with the aperture (use an inside calliper for measuring) and with the front end of the projection lens barrel, all is well. If not, then loosen nuts B B, Fig. 299 (four of them) and adjust nuts C C, Fig. 299 (four of them) until the rod is centered up and down and nut D, Fig. 299, until it is centered sidewise, after which tighten nuts B B down solidly.

NOTE.—It is possible to make a very good adjustment by merely centering the end of the rod in the aperture, but when it is centered with both the aperture and lens barrel we know it is exactly right.

CURRENT STRENGTH.—The General Electric Company builds its lamps to operate at a certain definite amperage and voltage. If you want the best results do not depart therefrom. If you do depart therefrom and trouble and damage to the apparatus results, do not blame anyone but yourself.

There are those who think that because they can operate an ordinary arc lamp at almost any desired amperage, they can do the same with the high intensity lamp. If you have any such idea you had better revise it, and come to an understanding of the apparatus you are handling. If your lamp is rated at 75 amperes and 60 volts, that amperage and voltage must be maintained for best results, though no serious damage will follow if the amperage does not run above 80 or drop below 70.

CARBONS.—Under no conditions attempt to use any other than high intensity carbons. Positive high intensity carbons are 11 m. m. (about 7/16 inch) in diameter by 18 inches long. Negatives are 11 m. m. by nine inches long, bevelled at one end. The General Electric Company recommends the use of National Carbon Company's High Intensity carbons.

NOTE.—In ordering carbons always give rated capacity of lamp.

INSTALLING NEW CARBONS.—By means of Knob Q move the positive carbon clamp E back as far as it will go and by means of crank R, move negative carbon clamp F down as far as it will go. Put negative carbon in first, push it through negative bafle plate G and down through clamp F until only about one inch of the tip remains above the face of the negative bafle plate G, as shown in Fig. 301. Tighten the screw of clamp F until the clamp grips the carbon firmly. Next shove the positive carbon through tube A, clamp E and positive contact shoes H, relieve the pressure of contact shoe by raising up slightly on the end of pressure arm so that carbon will slip through contact shoes H easily. Shove the carbon through until you have its tip as per Fig. 301. Tighten the screw in clamp E and the job is finished.

CAUTION.—Clamp E must grip the carbon tightly enough to carry the carbon forward against the friction of the contact shoes.

CAUTION.—While the carbons are long enough to run several reels, it is best, after each reel, to loosen clamps E and F and by means of Knob Q and crank R, bring them back to the end of their travel. Should you be caught without sufficient carbon to finish a reel (always supposing there is sufficient carbon in the lamp but that clamps E and F have fed forward as far as they will go) you can, by acting quickly, loosen the clamp screw and pull the clamp back while the arc is burning. This is, however, poor practice and if you run the clamp back after such reel you will not be compelled to resort to it.

DISTANCE CRATER TO FACE OF COLLECTOR LENS.—This will be a matter for experimental determination. Due to the difference in crater area per ampere and to the possible difference in heat of the crater, it will not be found practical to use the lens tables compiled for the ordinary arc. As the matter now stands we would advise you to determine what minimum distance you can carry your high intensity arc from the lens without undue breakage, and then use a 6.5 inch focal length collector lens and whatever focal length converging lens will give you the correct spot. This matter presents a problem which will have to be worked out. Watch the Projection Department. Data will be published therein as soon as possible.

OPERATION.—To strike an arc, first close the lamp motor switch. Next turn the negative hand adjustment crank R until negative is raised sufficiently to make contact with the positive, whereupon immediately separate the carbons, thus forming the arc. Now lower the negative until proper arc length is reached as per Fig. 301. Unless the arc length varies considerably no further attention will be necessary during the running of the reel, but if one carbon burns faster than the other, then hand adjustment will be required to re-establish proper arc length as per Fig. 301.

Should the positive carbon regularly burn away either faster or more slowly than the negative then an adjustment of the ratchet and pawl, which control the rate of feed of the positive carbon, should be made. This may be accomplished by loosening lock nut on set screw T, Fig. 300. Should the positive carbon be feeding too slowly, a turn of the set screw T toward the right, or in a clockwise direction, will cause the pawl to engage more of the teeth on the ratchet and in this way feed the positive carbon a greater distance for each revolution of the carriage. Should the positive carbon be feeding too rapidly, by turning screw T in a counter-clockwise direction, the reverse action from the above will take place. This pawl U, Fig. 300, should be adjusted until the proper rate of feed of the top carbon is established, after which lock nut on set screw T should be tightened. If this lock nut on set screw T should become loose, set screw T may be turned out of its correct position by the pressure applied to feed ratchet and pawl U during the operation of the lamp.

SHOULD THE POSITIVE CARBON AT ANY TIME FAIL TO FEED examine the ratchet and pawl adjustment and make sure that at each revolution of the carriage the ratchet engages with the pawl and that the ratchet is turned. Should this not be at fault, examine clamp E, making sure that the carbon is gripped tight enough to force it forward against the pressure of the contact shoe.

NOTE—Hand adjustment knob Q and crank R will work hard when turned by hand because to turn them you must overcome friction of clutches S, Fig. 300, and cause them to slip against the pressure of the tension spring thereon.

LAMPS IN SERIES.—High intensity lamps may be operated from a series type motor generator, exactly as are the ordinary projection arc lamps. The procedure, wiring, etc., is exactly the same.

HIGH INTENSITY A. C. OPERATION.—In case of emergency the G. E. High intensity lamp may be operated on A. C. In case your D. C. current supply should from any cause fail, first, since the lamp motor is a D. C. motor, disconnect it from all current supply. You may then connect the lamp to A. C. supply, either through an inductor, economizer, A. C. compensarc or any other similar low voltage transformer or through a suitable rheostat using the same carbons if the A. C. operation is to continue for but a few moments. If, however, you are to use A. C. for more than a few moments, then install a short high intensity positive carbon instead of the regular high intensity negative.

CAUTION.—Do not use the full rated D. C. amperage of A. C. About 3/4 the rated D. C. amperage is as much as you should use of A. C., which means that a lamp rated at 75 amperes D. C. should only be allowed 60 to 65 amperes A. C.

KEEP CLEAN.—Both the positive contact shoes H and also the opening in the asbestos baffle plate, directly behind them, should be kept clean and free from carbon dust. The contact surfaces on the positive contact shoes should be inspected every day. This may be done in the following manner:

Remove the screw holding the flexible metal ribbons, 5, Fig. 300, to the positive terminal, after which separate the arms sufficiently to release the coil spring and the entire positive shoe assembly can be lifted off the studs supporting it and thoroughly cleaned. The opening in the asbestos baffle plate should be kept clear and free from carbon particles.

The negative assembly does not require a great amount of attention, although care should be taken that the opening in the asbestos baffle plate G, Figs. 299 and 300, be kept clean and open so that the carbon may pass freely without binding. Care should also be taken that the negative carbon clamp F makes good contact with the carbon at all times.

EXAMINE TENSION.—Examine tension of positive current carrying contact shoes at least once, and preferably twice, a day. Tension must be sufficient to give firm contact and prevent arcing between carbons and clamp. Excess tension puts unnecessary strain on the motor and the carbon feeding mechanism; also it compels you to set clamp E unnecessarily tight.

THE MOTOR.—Motor brushes should be inspected at least every month; every two weeks, would be better. Use a good grade of machine oil in motor cups.

SPARE PARTS.—To guard against possible trouble and vexation, we would advise the projectionist to carry in stock the following spare parts: One positive contact shoe assembly, complete, shown at H, Fig. 300, for each lamp. One positive carbon clamp, shown at E, Fig. 300, for each lamp. One negative carbon clamp, shown at F, Fig. 300, for each lamp. One flexible wire jumper, shown at 3, Fig. 300, for each lamp. An extra pair of motor commutator brushes, for each lamp.

These parts are not expensive and they will be in the nature of insurance against possible trouble **See page 869.**

IMPORTANT NOTE: Full description of the Simplex High Intensity Arc Lamp, manufactured by the Precision Machine Company, Inc., will be found on pages 586 to 591 inclusive.

THE SUN-LIGHT AUTOMATIC HIGH INTENSITY LAMP

The complete Sun-Light automatic high intensity projection lamp has been designed in two separate units, viz.: the lamp unit and the automatic control unit. The lamp unit is shown in Fig. 303, and the automatic units in Figs. 304 and 305, which are respectively views of opposite sides of the unit.

The lamp unit consists of the adjustable mounting, or base and the carbon holders, contacts and the screws which feed the carbons. This entire unit is what the projectionist would term "the lamp." The adjustable mounting, or base is a simple arrangement—so arranged that by its manipulation the position of the arc crater may be changed, either up, down or sidewise. It consists of three main castings, viz.: the base, 5-201, Fig. 303; the swivel stand, 5-202, Fig. 303; and the lamp supporting bracket, 5-203, Fig. 303.

Base 5-201 is mounted on a coarse threaded screw by means of which the entire lamp may be moved backward or forward, thus altering distance of crater from lens. Swivel stand 5-202 is turned on its axis by screw 5-207, which connects with an adjusting handle or knob outside the lamphouse, as do all the other adjustment screws. This action moves the crater sidewise with relation to the lens.

Adjusting screw 5-210 raises or lowers the front end of the lamp by swinging lamp supporting casting 5-203 on the hinges formed by screws 5-211, Fig. 303.

The lamp proper is insulated from the base or adjustable mounting by means of an asbestos plate, 5-216, Fig. 303.

The main frame of the lamp, 5-1, Fig. 303, carries all the lamp parts, both positive and negative. The fact that the only contact between any part of the lamp and its base is at 5-216 reduces chances of grounding, because it is unlikely any object will come into contact with anything but the base.

On account of the high amperage and relatively small size of positive carbon, it would cause excessive heating to force the currrent through the entire length of the carbon. It has therefore been so arranged that the current enters the positive carbon through a heavy metal contact, 5-3, Fig. 303, the front edge of which is within 3/4 of an inch of the crater. This contact is held to the carbon by means of a metal shoe, 5-4, Fig. 303, by spring 5-5, Fig. 303, the action of which will be described further along. It is of the hairpin type (see Fig. 303½) and is located well away from any heat which could do it injury.

The positive carbon is held, or gripped in clamp 5-43 by means of screw 5-44, which bears directly on the carbon. It has a wide, flat point, but be careful and do not set down too tightly. If you do you may crush the carbon. It is not nec-

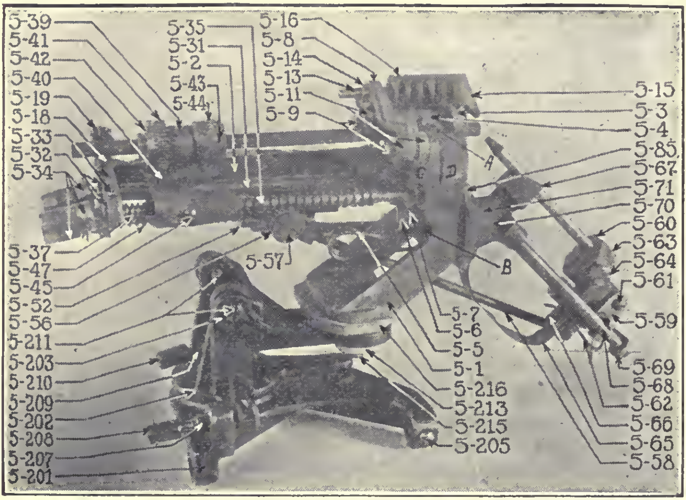


Figure 303.

essary to set the screw very tight, since the only office of the clamp is to carry the carbon forward against the friction of contact 5-4.

This carbon clamp, or holder is a hollow shaft on which is attached gear 5-41, which retains the holder in its bearing 5-39, the whole being a part of positive carbon carriage 5-39, which includes the casting riding on positive feed screw 5-35 and rod 5-31. Gear 5-41 and clamp 5-44 rotate together, as one part, with part 5-39 acting as a bearing for the shaft they ride on, the whole being shoved ahead or pulled back by feed screw 5-25. All numbers refer to Fig. 303.

We have tried to make this very clear because it is essential that you understand the action of the carriage in order that you may understand the other details.

The positive carbon is rotated semi-continuously by gear 5-41, which is itself driven by a small gear immediately under it, 5-50, Fig. 303. This latter gear is carried along rod 5-31 as the carbon carriage moves forward, but it makes positive driving contact therewith by means of a slot in the shaft into which a key in the hole of the gear fits; shaft 5-31 being rotated semi-continuously by means of ratchet 5-121, Fig. 304. The reason we say the rotation is semi-continuously is that while the action is to all intents and purposes continuous, still it is accomplished by means of pawl 518, Fig. 304, acting on its ratchet, hence it is not a strictly continuous movement. The feeding forward of the positive carbon is by means of a coarse threaded screw 5-35, which moves the whole positive carbon carriage forward, or pulls it back when necessary. The feeding of the positive carbon is not continuous, but is automatic and intermittent. The feed is designed to maintain the crater in a position, the possible variation from which is fixed within certain very definite and very small limits.

THIRD ELECTRODE.—The position of the positive crater and the feeding of the positive carbon to the arc is accomplished by a "third electrode" system, the main element of which is numbered 5-15, Fig. 303. The third electrode, 5-15, is a ribbed casting of a heat resisting metallic alloy. It is mounted just over the front end of the positive carbon, and is insulated from both positive and negative parts of the lamp. This later is accomplished by means of bracket 5-8, Fig. 303, which is insulated by material 5-11, Fig. 303.

HOW IT WORKS.—By means of screw 5-13, Fig. 303, the third electrode may be shoved ahead or retarded, and it is the position of the front tip of the third electrode with relation to the tip or end of the positive carbon which determines the position of the crater, or in other words, its distance from the face of part 5-3, Fig. 303. If part 5-15 be moved further out, then the crater will form further out, or vice versa. Part 5-15 should be so adjusted that the crater will form about 3/4 of an inch from the face of part 5-3, Fig. 303.

CAUTION.—After making an adjustment of the position of part 5-15 always tighten lock nut 5-14.

From part 5-15 an asbestos covered wire extends back to terminal 5-19, which connects with the automatic unit control, the operation of which will be described further along.

The feeding of the positive carbon is accomplished through the third electrode as follows: When the arc is burning normal, with the crater in its proper position, the flame from the arc does not touch the third electrode, but shoots up past it. As the crater burns back, however, the flame, which is a fairly good conductor of electricity, touches the face of the third electrode. This completes a circuit, energizes a magnet and sets the automatic unit to work feeding the positive carbon forward until the flame is out of contact with the face of the third electrode, whereupon the circuit is broken and the positive carbon feeding instantly stops until contact is made again between the face of the third electrode and the flame.

The action of the automatic unit in this respect will be explained in detail further along.

THE NEGATIVE carbon is at an angle of 45 degrees to the positive, which latter lies horizontal. The negative is not rotated, but is fed up to the arc by means of a coarse threaded screw located just back of screw 5-35, Fig, 303, which acts through connecting rod 5-58, Fig. 303. Rod 5-58 connects negative carriage 5-59 with the feed screw through hinge joint 5-56, of which screw 5-57 is the hinge pin. The hinge is necessary because the feed screw lies horizontal, and pulls 5-56 along horizontally, while negative carriage is pulled up at an angle. Feeding of the negative is by means of ratchet 5-120, Fig. 304. It will be described under "the Automatic Control Unit."

Screw 5-57 and part 5-52 with which it connects (which rides on the feed screw) are insulated from part 5-56 and connecting rod 5-58.

The negative carriage slides up and down on two round rods, one of which is numbered 5-68, Fig. 303. Set screw 5-64 clamps the negative carbon in its holder, or clamp. This screw should be kept well lubricated with graphite. The negative carbon carriage is hinged at its bottom, screw 5-61 being the hinge pin, which allows spring 5-62, Fig. 303, to pull the upper end of the carbon down into current carrying contact 5-67. Both carbon clamp 5-63 and contact 5-67 carry current, and in emergencies either may carry all the current, though to avoid excessive heating of the carbon it is intended that the upper contact carry most of the current. It is therefore essential that you keep contact 5-67 perfectly clean, and that you test the tension of spring 5-62 frequently. Every time you put in a new negative is none too often. Test by pulling the top of negative outward to raise it out of contact 5-67. You will soon learn to judge whether the tension is right or not.

YOU SHOULD HAVE EXTRA SPRINGS, and if you find a spring is getting weak, or has lost its temper, remove negative carbon and take out hinge screw 5-61, Fig. 303. You may then lift negative carbon holder off top end of spring and, using a screw-driver, pry the tip of the spring out of the casting, insert the tip of the new one and reassemble the parts. The whole operation should not consume more than from three to five minutes.

Contact 5-67 also serves the purpose of keeping negative carbon always in perfect alignment.

Care should be taken to sweep top of insulating material 5-85, Fig. 303 clean every day. Do not allow dirt or carbon dust to accumulate on any insulating material, or elsewhere for that matter.

The entire negative carriage may be removed from the lamp by taking out two hexagon headed bolts, one of which is part 5-70, Fig. 303, removing screw 5-66 to disconnect strap 5-65, and disconnecting lower end of rod 5-58, Fig. 303.

NOTE.—You should have an extra current carrying strap 5-65. You may not need it, but since the strap is subject to constant movement it may, in course of time, give way.

CLEAN POSITIVE CONTACT.—Positive contact 5-4 should be removed occasionally and thoroughly cleaned and examined. To do this, first loosen the screw at lower end of current-carrying strap 5-6, Fig. 303. Next remove lock nut 5-14 from the stem of third electrode 5-15, Fig. 303, and remove the third electrode itself by screwing stem 5-13 out of bracket 5-8, Fig. 303.

Next, with the right hand grasping spring 5-5, compress it and, using a screw driver, pry the loop at its upper end off of ear A, Fig. 303 and take the spring out. This releases all the parts, which may be lifted out, inspected and cleaned. First lift off part 5-4, Fig. 303, which is loose-hinged at its left hand end. You may then lift out part 5-3.

NOTE.—When you have part 5-3 out you will note at its lower end a V-shaped recess in the main frame of the lamp, into which part 5-3 fits. Examine carefully **and make sure there is no arcing between part 5-3 and the frame.** If there is it is evidence that current-carrying strap which connects at its lower end to the lower end of part 5-3, is not making good electrical contact. Clean the parts thoroughly and examine both contacts of the strap, locate the trouble and fix it.

CAUTION.—Reassembling is but the reverse of the process of disassembling, just described, but be carefully to tighten nuts of current carrying strap 5-6 down firmly.

The end of spring 5-5, Fig. 303, indicated at B, should set in the small ear on the side of contact piece 5-3. The form of this spring is shown in Fig. 303½. Between part C and the front wall of D is a recess, up through which the long end of the spring passes, its upper end hooking over an ear on the end of part 5-4 at A, Fig. 303.

NOTE.—Should the projectionist be so careless as to allow the positive carbon to burn away until the front end of positive carbon carriage strikes the frame of the lamp at C, Fig. 303, while the motor will not be stalled because of spring 5-37, which enables the motor to keep running, still it is possible the crater will then burn back far enough to burn away the tip of third electrode 5-15. In case it does, however, you may still secure perfect arc regulation by advancing the third electrode until its face occupies the position necessary to maintain the crater the correct distance from part 5-3. In other words, the third electrode will work without the tip, but you will have to set it further forward.

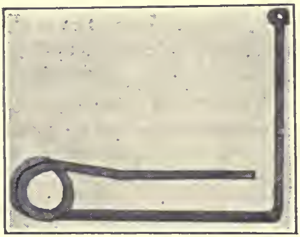


Figure 303½.

IN EMERGENCY.—Such a thing should never happen, and never will happen if proper care be exercised, still in event a reel is started with a positive too short to finish it, it is possible to "get by" as follows: Loosen screw in clamp 5-44, Fig. 303, and insert a new positive carbon behind the old one. Now, by hand, very carefully shove the carbon in, pushing the old one ahead just enough so that the flame clears the third electrode and the crater is kept in its approximately proper position. This will take very careful work, but it can be done. Understand that this is only to be done in case of genuine emergency, when the projectionist has miscalculated and has not sufficient positive carbon to finish a reel.

SPARE PARTS.—You should carry the following spare parts for the lamp. None of them is expensive.

One current carrying strap 5-65, Fig. 303.

Two springs 5-5, Fig 303.

Three or four springs 5-62, Fig. 303.

One third electrode for each lamp, 5-15, Fig. 303.

One each 5-3 and 5-4 for each lamp.

Half a dozen screws 5-45, Fig. 303.

Set insulating tubing and washers, 5-17, Fig. 303.

THE AUTOMATIC UNIT PANEL.—In considering Figs. 303 and 304 let it be understood that universal joints 5-34 (3 of them) Fig. 303, connect respectively to 5-120, 5-121 and 5-119, Fig. 304.

The automatic control unit is shown in Figs. 304 and 305, they being views of opposite sides, Fig. 304 having the mechanism cover, 5-102, removed. The control is mounted on the outside of the back of the lamphouse. The unit contains the driving motor and all the mechanism for feeding the carbons, rotating the positive carbon and automatically maintaining the crater of the arc in the required position.

Motor 5-104, Fig. 304, supplies all necessary power. It runs continuously and on arc voltage. The motor armature shaft is coupled, by means of spring coupling 5-105, Fig 305, to a worm and worm gear mounted in worm gear housing 5-108, Fig. 305. Access to gears may be had by removing screws 5-139 and cover 5-109, Fig. 305. The small cap 5-110 should be removed occasionally for inspection and the repacking of the worm with grease. Use good grade automobile grease for this purpose. On the other end of its shaft the worm gear carries crank 5-113, Fig. 304, and it is this crank which feeds both carbons and rotates the positive. The crank rotates at the rate of about 100 revolutions a minute, or approximately three times around in two seconds.

The slot in the upper end of upper arm of rocker arm 5-114 Fig. 304, engages with the pin on crank 5-113, therefore, since the rocker arm is pivoted on a stud, the cap screw of which is numbered 5-115, Fig. 304, it follows that when the crank revolves the rocker arm will swing, or rock, and since pawl 5-117 is attached to its left-hand end and pawls 5-118 and 5-116 are attached to its right-hand arm, these pawls will be lifted up and down with each revolution of the crank.

Pawl 5-118 is held in continuous engagement with ratchet 5-121 by means of coil spring 5-126 and ratchet 5-121 is connected, by means of a square shaft, with shaft 5-31, Fig. 303, which is the shaft which drives gear 5-40 and 5-41, Fig. 303, which same rotate the positive carbon. The rotation of the positive carbon is, therefore, to all intents and purposes continuous, as long as the motor runs.

Pawl 5-116 is held just out of engagement with ratchet 5-119, which ratchet connects with positive carbon feed screw 5-35, Fig. 303. The positive carbon, therefore, will not be fed until some agency pulls the pawl into engagement with the

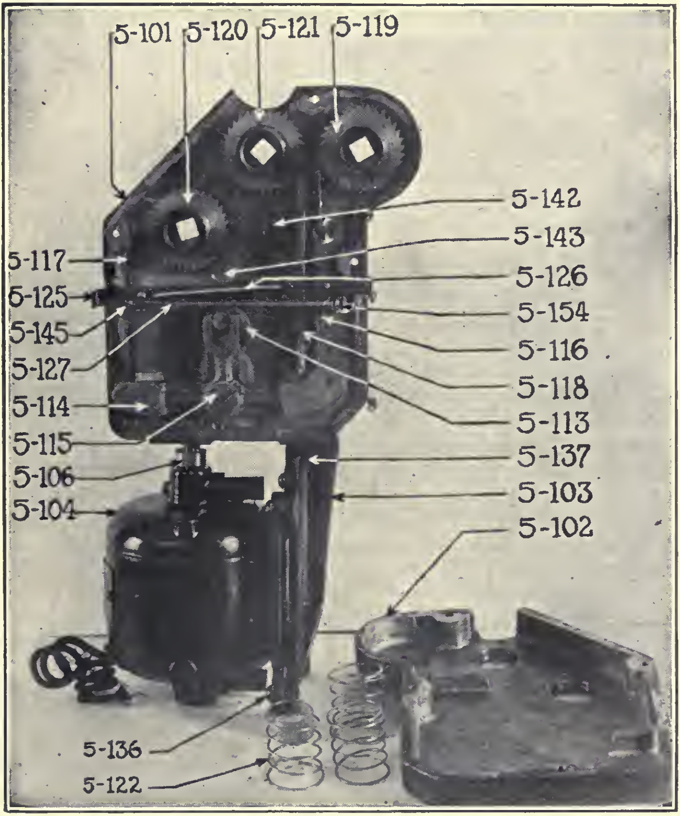


Figure 304.
Automatic Control Unit with Cover Plate Removed.

ratchet, and here is where the third electrode steps in. When the crater burns far enough back that the flame strikes the third electrode, as already set forth, a circuit is completed through the flame, which energizes magnet 5-130, which causes armature arm 5-134, Fig. 305 to pull pawl 5-116 into engagement with the ratchet and since the pawl is being continuously lifted up and down the ratchet is rotated and the positive carbon is fed forward until the flame is out of

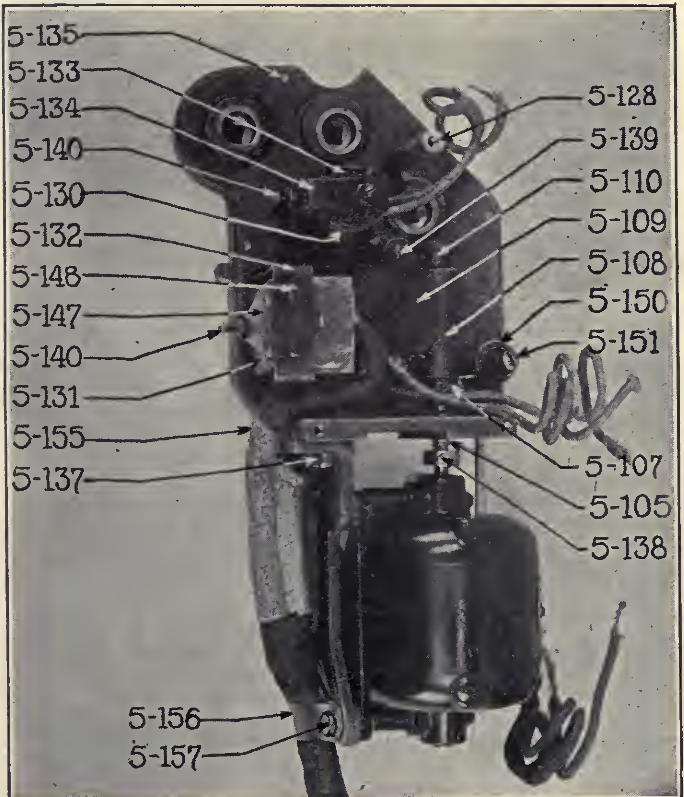


Figure 305.

Automatic Control Unit—Back View.

contact with the third electrode, whereupon the feeding stops, to be automatically begun again as soon as the flame again strikes the third electrode and thus re-energizes the magnet.

The feeding of the negative carbon is controlled by the arc voltage, and is entirely independent of the feeding of the positive carbon. The effect of positive carbon control is to maintain the crater in a fixed position, and the effect of voltage control of the negative feed is to automatically maintain a certain, fixed arc length. Both of these are good. The negative feed works as follows. The magnet controling the negative carbon feed is numbered 5-131, Fig. 105. One of its terminals is attached to the positive and the other to the negative side of the line near the lamp. In addition to this connection, which is in the nature of a shunt, the magnet frame itself carries a few turns in series with the arc, numbered 5-155, Fig. 305, composed of heavy asbestos covered wires. This series winding acts as a compensator for changes in current at the arc, hence has the effect of maintaining a fixed arc length, regardless of current fluctuation.

The method of operation is as follows: As the negative carbon is consumed the arc becomes longer, hence the arc voltage is increased. This increases the pull of magnet 5-131, which causes magnet arm 5-132, Fig. 305, to move over, carrying with it pawl 5-117. Fig. 5-304, to which it is attached by connecting bar 5-127, Fig. 304, until the pawl comes into contact with ratchet 5-120, which connects to negative carbon feed screw 5-47, Fig. 303, and since the ratchet will thus be rotated the negative carbon will be pulled upward until the arc is shortened, and its voltage thus decreased until the magnet no longer has sufficient energy to hold the pawl in contact with the ratchet, whereupon feeding automatically stops until the process is repeated.

The arc voltage may be adjusted at any desired value by means of tightening or loosening knurled knob 5-150, Fig. 305, which is held to the main plate by screw 5-151. Twisting knurled knob 5-150 increases or decreases the tension of a coil spring, not shown in illustration, according to the way it is turned. Increase of tension increases length of arc, and vice versa.

CAUTION.—This adjustment is very sensitive. The knob should be turned just a very little at a time, and its effect noted. Any considerable turn will throw the adjustment clear out and probably cause considerable trouble before you get it right again.

The claim of the manufacturer is that the control is such that both the positive crater and the tip of the negative carbon will be kept within 1/32 of an inch of their fixed position for an entire trim of carbons, without any attention on the part of the projectionist, and with no possibility of the positive crater working slowly out of position.

HAND FEED.—Both the rotating shaft and both carbon feeds have auxiliary hand feed controls, so that the lamp may at any time be operated by hand. By moving small slide bar 5-125, Fig. 304 to the left, both automatic carbon feeds will be cut out by stops on the slide bar which hold the feed pawls out of engagement with their ratchets.

CAUTION.—After striking the arc, and before you do anything else, be sure the slide bar is pushed to the right, and that the automatic feeds are functioning properly. If the automatic feeds are cut out and the projectionist does not feed the lamp by hand, damage may and probably will be done to the tip of the third electrode by the burning of the positive crater back under it.

The automatic control unit is attached to the lamphouse by means of three screws, one of which is in stud 5-128, Fig. 305, and the other two in the holes in the cross plate just above the motor, Fig. 305.

Cover 5-102, Fig. 304, attaches by means of four screws. The three springs beside the cover slip over the ratchet hubs, hold them in their bearings and supply enough friction that the ratchet will not be dragged backward by the receding pawls.

In replacing cover plate 5-102, Fig. 304, be careful that the three springs are in their proper places, that slide-bar 5-125 is seated in its groove and that none of the parts bind, due to pressure of the cover plate. The freeness of the pawls may be tested by pressing the finger on the magnet armatures, noticing whether or not they move easily and travel their normal distance, or until the armature is stopped by the adjusting screw.

The following spare parts should be carried for the Automatic control units: **(See page 869.)**

Two sets motor brushes.

Two negative feed magnet springs, 5-149.

Two spring coupling, 5-105.

The Spotlight

THE projectionist is sometimes called upon to operate a spotlight, and if without experience may feel nervous about making the attempt. This is unnecessary, as the apparatus is simple and easy to manipulate. It consists essentially of a lamphouse, similar to the ordinary motion picture projector lamphouse, in which is an ordinary arc lamp similar to the arc lamp used for projecting motion pictures. There is an arrangement by means of which the lamp may be quickly advanced or pulled back in order to alter the distance of the crater from the lens, since it is this act which alters the size of the "spot," or changes it to a "flood." In the front of the lamphouse a single plano-convex lens is mounted. There are no other lenses in connection with a "spot," as such devices are called. The lamphouse is mounted on an upright, which is adjustable in length, so that the height of the lamphouse from the floor may be changed at will. The upright is supported by a suitable base. On some of the smaller spots a small wire coil rheostat is mounted, but with most modern spots the rheostat is a separate unit.

The lamphouse is so mounted that it may be swung from side to side, or tilted up or down, since by these movements the direction of the light beam is directed.

Roughly this decsribes the old type "spot," which same is illustrated in Fig. 307. In Fig. 306 we have a view of the optic end of it.

The lens usually is six inches in diameter for small spots, though larger ones may have lenses eight inches in diameter. There is a single plano-convex lens only.

As said before the size of the "spot" is controled by the distance of the crater to the lens. The further away it is the smaller the "spot," and the closer it is the larger the "spot." If it be shoved close enough to the lens a "flood" will result, which may be made to cover the entire stage.

Spot lights use anywhere from fifteen to fifty or more amperes D. C., which is taken through an ordinary rheostat of suitable capacity.

HANDLING A SPOT.—No especial skill is required to handle a "spot." A man of ordinary intelligence should, after a few moments practice, be able to cover an actor when moving about, and do it well, too. The difficulty is not in handling the device, but in the matter of carbon setting. With the old style arc lamp considerable experience and skill is necessary to get an approximately round spot which is free from ghost. The spot is nothing more or less than an out-of-focus photograph of the crater of the positive carbon, therefore, unless the crater presents a round surface or circumference to the lens, the resultant spot will not itself be round; also faulty carbon setting is likely to produce a ghost in the spot.

The lamp should be given a pretty heavy angle, and the carbons should be set much the same as for motion picture projection. It is then up to the projectionist to experiment with the amount of advancement of the lower carbon tip

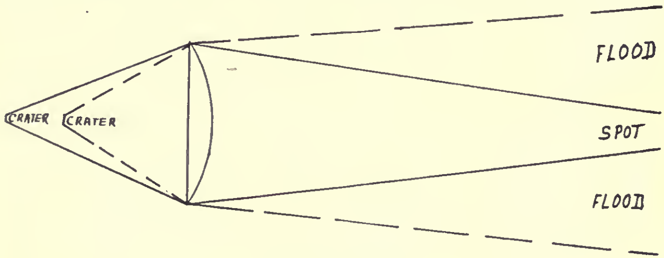


Figure 306.

with relation to the other, and with the angle of the lamp itself, until he gets the condition which produces the most nearly round spot, and one free from ghost.

KIND OF CARBONS.—It will, of course, be necessary to use a cored carbon for positive. Any good projection carbon will do. For negative the projectionist may try a cored carbon, of smaller diameter than the positive, and a Silver Tip and Hold Ark, using the one giving best results.

Remember that following an actor with a spot is childishly simple. **The hard job is to get and keep a clear, round spot.**

The spotlight port in the wall should be 16 to 18 inches in diameter, round or square, as preferred. A color wheel suitable for mounting on a spot may be had from any supply dealer. It is a very necessary adjunct to a spot light. Color slides may also be had.

A. C. SPOT.—We do not advise you to try it, unless you use pretty high amperage. It is possible to get a spot with

A. C. at ordinary amperage, but it will not be a good one. Seventy-five amperes is what we would consider as the minimum amperage for a spot light, if good results are to be had.

HIGH INTENSITY SPOT.—The Nicholas Power Company is marketing a spot which uses the high intensity lamp. This spot is, in many respects, a distinct innovation.

The base is heavy and has three extensions or "feet," one of which is about four inches longer than the others. The long leg goes toward the back of the lamphouse. The lamphouse is 29 inches front to back, 31 inches from base to top of vent cone, and 11½ inches wide. It is made of heavy material, with double-wall doors. Adapters are provided, which enable the use of anything from a 4 to an 8-inch diameter lens. These adapters fit into a groove in casing A. In front of the lens, also fitting into a groove in casing A, is an iris diaphragm with an 8-inch opening, constructed entirely of brass. In front of the iris are two grooves, designed to carry either the support for a color wheel, or color slides. The observation window in the lamphouse is 10 inches long by 3 inches wide, and is covered with dark red glass. Casing A is of grey cast iron.

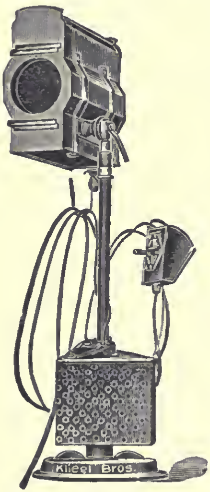


Figure 307.

The construction is such that once the spot is in the desired location it may, if desired, be locked there by means of wheel B and handle C. By loosening wheel B the lamphouse may be swung clear around on the pedestal. Handle C is a locking device, so that the lamphouse may be tilted to any desired angle and locked there. With both handles B and C unlocked the spot may be moved to any desired location, from on the floor three feet in front of or back of the machine, to an angle of probably 75 degrees upward.

The machine, exclusive of the pedestal, weighs probably 150 pounds, yet so perfect is the construction and the balance that it may be moved in any direction with one finger; also, the balance is automatically maintained, regardless of the position of the lamp, because when the lamp is pulled back, weight D automatically moves forward just enough to counterbalance the weight of the lamp. Handle E controls the forward and backward movement of the lamp and the weight. Rod F has teeth on its under side and rod G teeth on its upper side. Between these two rods is a toothed wheel. This wheel is actuated by rod F when the lamp moves forward or backward, and this, acting through the toothed wheel, moves rod G in the opposite direction, thus

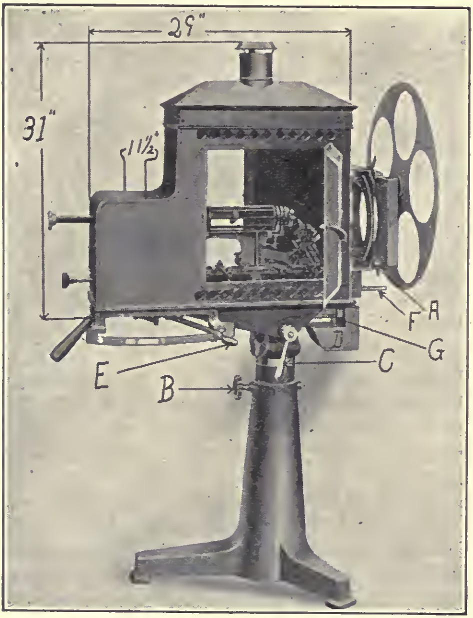


Figure 308.

carrying weight D backward and forward to counterbalance the weight of the lamp, and thus keeps the lamphouse always evenly balanced on the pedestal.

The spot marks a very great step forward in the production of high-class equipment for theatres.

DATA CONCERNING SPOTLIGHT LENSES.—The Universal Stage Lighting Company, better known as Kliegl Brothers, 321 West 50th street, New York City, from whom spotlight lenses of all sorts may be had, supplies the following valuable data:

"We are very often requested to supply a lens to give a small (5 foot) spot when the distance of projection is long. **It is not possible to handle such requests intelligently unless the following information accompany the order:** (A) Distance lens to stage; (B) diameter lens the spotlight will accommodate; (C) length of spotlight hood, or greatest distance crater can be gotten from face of lens.

"Our regular 25-ampere stage spotlight, which uses either a 5 or 6 inch diameter lens, will give an excellent three (3) foot spot at any distance up to 40 feet. This spotlight cannot be used to give a five foot spot at 100 feet, because the hood is not long enough. In other words, it is impossible to get the crater far enough from the lens.

"The following data will be of assistance to the projectionist, or to the spotlight operator who may wish to obtain a five foot spot at various distances. You will note that some lenses give the same size spot at widely different distances, without altering distance of crater to lens. This is because at the outer end of the beam its diameter varies but little over a long distance.

"**NOTE.**—Before ordering lenses it is of the utmost importance that you try your lamp and see if you can get the crater the required distance from face of lens. If you cannot, then you cannot get the results you want unless the length of hood be altered so that you can get greater distance between crater and lens.

"To gain a five foot spot at longer distance you must be able to get the crater back a greater distance, but it must be considered that the further the crater is from the lens the greater will be the waste of light—see page 162, hence when crater-to-lens distance is increased the amperage must also be increased if the brilliancy of the spot is maintained. For this reason our long distance spot lamps are equipped with a 35, 50, 70 and 100 ampere rheostat."

IMPORTANT.—It is essential that proper carbons be used. If this be not done there will most likely be shadows, rings and lack of brilliancy in the spot. It is not sufficient—in fact it will not do for the projectionist or spotlight operator to place a pair of ordinary ⅝ths cored carbons in the lamp. With direct current, cored projection carbons must be used for upper and solid "Silver Tip" carbons for lower. When using A. C. use cored white flame carbons.

To obtain approximately a five (5) foot diameter spot.

Distance lens to stage	Diameter of lens	Focal length of lens	Distance crater must be from face of lens to obtain 5 ft. diameter spot
75 feet	5 inches	9 inches	7 inches
100 feet	5 inches	9 inches	8¼ inches
75 feet	6 inches	12 inches	11¼ inches
100 feet	6 inches	12 inches	11¼ inches
150 feet	6 inches	12 inches	11¼ inches
75 feet	6 inches	13 inches	12″ for 4′ spot
100 feet	6 inches	13 inches	12″ for 4′ spot
125 feet	6 inches	13 inches	12″ for 4′ spot
150 feet	6 inches	13 inches	12¼″ for 4′ spot
75 feet	8 inches	13 inches	12½ inches
100 feet	8 inches	13 inches	12½ inches
125 feet	8 inches	13 inches	12½ inches
150 feet	8 inches	17 inches	12½ inches

IT TAKES LESS TIME TO DO A THING RIGHT THAN TO EXPLAIN WHY YOU DID IT WRONG

Stereopticon

EVERY projection room should be equipped with a stereopticon, though a dissolving stereopticon is no longer necessary in most moving picture theatres.

In the early days of the business the almost universal custom was to project stereopticon slides designed to "illustrate" the words of a song sung, at the same time, by a singer. This practice has almost entirely ceased, and with its passing the need for a dissolving stereopticon has also very largely ceased. A small, single stereopticon is all that is ordinarily necessary in the modern projection room.

Many exhibitors do not provide even this, utilizing instead a motion picture projector stereopticon attachment. This of course can be done, but there are serious objections to the plan, one being that the condenser suitable for the projection of motion pictures under a given condition, is very seldom suitable for the projection of slides when the projection distance is the same, and the height of the "still" is limited to the height of the moving picture because the latter is bordered in black, and even though it be only advertising slides that are projected, the job ought nevertheless to be done in the best possible manner. See "Combination Projector," Page 802.

The single stereopticon consists of a lamphouse and lamp, a condenser, a slide carrier and a projection lens. The assemblage may be had with or without a supporting stand.

SLIDE SIZE.—Slides used in the United States and Canada measure 3.25 inches by 4 inches over all. The actual opening in the mat, or the size of the picture as outlined by the paper mask, is presumed to be two and three-quarters inches by three inches, though in practice the size of mat openings vary widely from this measurement.

Due partly to the fact that the revolving shutter of the moving picture projector cuts about fifty per cent. of the light, and in part to the fact that a still greater percentage of the total light is wasted at the spot, whereas with the stereopticon the entire beam of light from the condenser is available at the screen, less only the relatively small percentage lost in the projection lens itself, stereopticon pictures may be projected with a very much less brilliant light source than is necessary with motion pictures. With a properly selected optical system the stereopticon will project a very excellent picture sixteen to eighteen feet wide with 15 amperes D. C. As a matter of fact high amperage for stereopticon projection is objectionable, because the resultant heat may and probably will crack the slide if it be left in the light for more than a very brief period of time.

This is another reason why a stereopticon should be installed in the projection room if any slides at all are to be projected. If the theatre projects slides advertising future programs they miss their purpose unless left on the screen a sufficient time to be read by the audience, and this can hardly be done when they are placed right up against a hot condenser through which the light from the 50 to 100 ampere crater is passing. Then, too, where a Mazda light source and a prismatic condenser is used for moving picture projection, slides cannot be projected with it at all.

GAS LIGHT.—So little light is necessary for the proper projection of stereopticon pictures that it is possible to get excellent results by the use of ozo-carbi, lime-light, or even by the use of acetylene gas.

WHY CRACKED CONDENSERS SHOW.—Many amateur projectionists are puzzled by the fact that whereas a crack in one of the condenser lenses will not show on the screen when projecting moving pictures, it shows very plainly when projecting still pictures.

The answer is simple. In the stereopticon the slide and the screen represent the two conjugate foci points of the projection lens, therefore it is the slide that is focused at the screen, and since the condenser is right up against the slide, any imperfection therein will also be more or less sharply focused at the screen. It therefore follows that a crack will show, and, if it be in the converging lens will show very sharply, because the face of the converging lens is practically at the conjugate foci point. On the other hand, with the moving picture projector, since it is the screen and the film that are the conjugate foci points of the projection lens, and the condenser is removed from the conjugate foci point (film) by many inches, any imperfection therein will not be focused at the screen, therefore an imperfection such as a crack in the condenser will not show, even though it be a very bad one.

SLIDE CARRIER LIGHT LOSS.—If the optical system of a moving picture projector be such that the projection lens will pick up the entire beam from the full diameter of the condenser (about 4.25 inches), then the placing of a slide carrier permanently before the condenser lens will operate to cut down the illumination at the screen, and cut it down very considerably, too. See Fig. 42 A, Page 177. If, on the other hand, the condition be such that the projection lens is unable to pick up the beam from a condensing lens more than three inches in diameter, then the slide carrier will cause no loss. As a general proposition, however, we would very strongly advise against the permanent location of a slide carrier in front of the condensing lens of a moving picture projector. Under some conditions it does no harm, but under other conditions it will cause a very great loss of light, and one can never tell whether or not the man in charge of any particular projector will be able to determine whether the carrier is doing damage or not, hence, the safest way is to avoid the installation of a carrier in front of the lens.

COMBINATION PROJECTOR.—Whereas we strongly advise against using the moving picture projector stereopticon attachment, still we realize that it is being done in many cases, and probably will be for some time to come. If the attempt is made to project slides with the current used to project moving pictures there will probably be a great number of them broken. This cannot be entirely avoided if a projector be used for slide work immediately after moving pictures have been projected, because the condenser will in that case be very hot, and the heat stored therein will break the slides if they be left in the carrier for more than a few seconds. Slide breakage may be avoided, however, by using the projector which has been standing idle, and reducing the current. If A. C. is used at the arc, and current is taken through an economizer, the current reduction is merely a matter of tuning the adjustment lever to low. If rheostats are used, the matter may be taken care of either by installing a rheostat of suitable capacity in a shunt circuit, as shown at A, Fig. 309, or by second rheostat in a shunt circuit, as shown at B, Fig. 309, so that when the switch is closed the resistance rheostat D is eliminated, but when the switch is open the two rheostats are in series, which will reduce the current to any desired number of amperes, the amount of reduction depend- on the amount of additional resistance offered by rheostat D.

If a motor generator set is used the amperage may be reduced by means of the field rheostat when slides are to be projected. It is also quite possible to so arrange a rheostat that it may be cut into series with the generator of a motor generator and the arc, as per the shunt circuit at A in Fig. 309; in which case there would, of course, be no rheostat B, the shunt being merely connected around the switch.

With a mercury arc rectifier of modern type it is possible to reduce the amperage for slide projection merely by moving the dial switch to "low."

No matter what apparatus you have for supplying current you can arrange to reduce current for slide projection if you know your business, always provided the exhibitor will provide what, if anything, is needed to do it.

THE DISSOLVER.—The dissolving stereopticon consists of what amounts to two separate, single stereopticons,

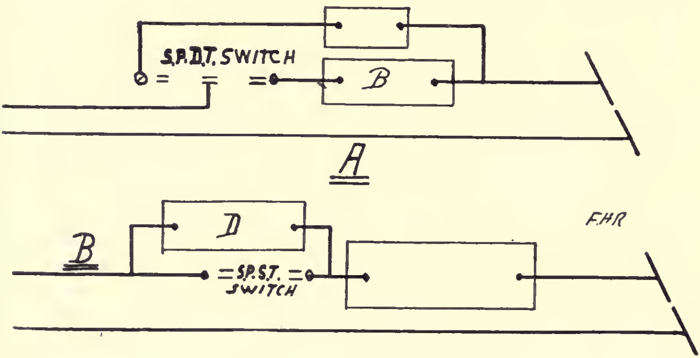


Figure 309.

mounted on one base, usually one above the other, with an arrangement either in front of or attached to the projection lenses, by means of which the closing of one lens automatically opens the other, or vice versa, the opening of the one lens being in exact proportion to the closing of the other, so that, for instance, when one lens is half open, the other automatically is half closed, and when one is entirely closed the other is wide open. This latter is known as the "dissolving shutter."

The reason it is called "dissolving" is as follows: Supposing one lens to be wide open and a picture being projected through it to the screen. We start to open the other lens by moving the handle of the dissolver, which at the same time starts to close the open lens, so that a second picture is projected through the opening lens with constantly increasing brilliancy, as the brilliancy of the picture already on the screen is gradually diminished by the closing of its lens. The opening and closing is in exact proportion, so that at the time both lenses are exactly half open there are actually two pictures on the screen, each of exactly equal brilliancy, the total effect being that the second picture is "dissolved" into the first, or the first is "dissolved out" by the second.

There are two advantages in the dissolver as against the single stereopticon. First, the dissolving out of one picture by the other is a much more pleasing effect than can possibly be had with a single stereopticon. Second, when using a single stereopticon, unless the projectionist is very careful

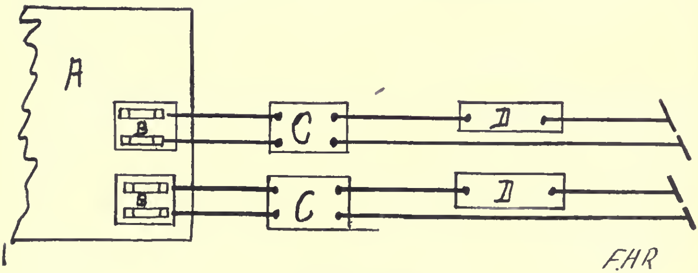


Figure 310.

while removing or inserting slides, he will move the carrier, which will cause the picture on the screen to move or jump. This is not possible with the dissolver.

It is, however, hardly worth while to go to the expense of a dissolver if only advertising slides are to be projected. The careful, painstaking projectionist can avoid movement of the picture on the screen while inserting the second slide, and by the use of an Ingento Slide Carrier not only is movement of the picture on the screen avoided, but the change of pictures on the screen is made very rapidly, and with a semi-dissolving effect, therefore

Where advertising slides only are to be projected, we would recommend a small, single stereopticon, equipped with an Ingento dissolver, which latter may be had of any good supply dealer. Such a stereopticon may be equipped either with

Mazda or arc lamp light source, but Mazda will serve every purpose, and serve it well.

In Fig. 310 the electrical circuits of a dissolver is illustrated. A is the projection room switch board, B-B the fuses for each circuit, C-C, the dissolver table switch for each circuit, D-D the two rheostats, one of them for each circuit. A dissolving stereopticon requires two complete circuits—just as complete as though each were the circuit of a single stereopticon, which it, in fact, is. Rheostats should not exceed 20 amperes D. C. capacity, and if properly handled, 15 amperes D. C. will be plenty, provided the optical system be what it should be. If the light source be an A. C. arc, then a considerably higher amperage will be necessary—say 30, 35 or even 40.

Where a dissolver takes current through a single economizer it is possible to connect as per Fig. 311, though it re-

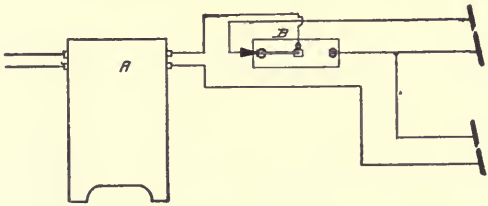


Figure 311.

quires considerable practice to handle the arcs, and unless handled skillfully they will go out. In Fig. 311, A is the economizer and B a D. T. S. P. knife-switch of suitable capacity. With the switch in position as shown, the two lamps are in series. To start the arcs it is necessary to freeze the carbons of one lamp, and then strike the arc of the other, after which the carbons of the second lamp may be separated, and the second arc thus formed.

This can be, and has been done, but as we have said, it is difficult to handle the arcs, and unless one has considerable practice there may be times when the picture on the screen will suddenly vanish.

The same thing can be done with rheostats, but rheostats are so low in cost that there would be no real necessity for attempting so difficult a thing.

DISSOLVING SHUTTER.—The best dissolving shutter consists of an iris diaphragm affixed to each projection lens, the two so connected that the closing of one opens the other, or vice versa. However, anything that opens one lens in proportion as the other is closed accomplishes essentially the same effect, and it is entirely practical for the projectionist himself to make a dissolving shutter which will work nearly as well, insofar as screen results be concerned, as the iris diaphragm. This is illustrated in Fig. 312, in which diagram A and diagram B show two different ways of doing it. In A, two metal shutters, with saw-tooth edges, are attached to an iron bar of proper length, the same being mounted on a bolt X which is attached to the projection room wall, and operated by handle Y. The only thing to be sure of is that the shutter be so made and placed that when one lens is exactly half open the other is half closed.

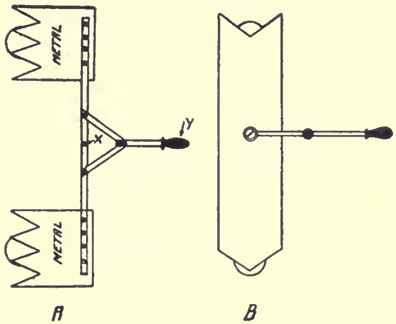


Figure 312.

At B the same thing is accomplished by means of a board, cut as shown. Instead of rocking sidewise this board raises straight up and down. The bolt by means of which it is held is, as in the case of A, attached to the projection room wall. In the latter case there must be either a counter weight on the handle, or some kind of a friction device on the sustaining bolt, which will prevent the shutter dropping down by its own weight.

PROJECTOR STEREOPTICON DISSOLVING.—It is quite possible to arrange a dissolving effect where the projectionist has two moving picture projectors, each equipped with a stereopticon attachment. We do not advise this, but it can be done. It is only necessary to arrange a shutter somewhat similar to A, Fig. 312, but with the blades sliding up and down in grooves in front of the lenses, instead of being attached to a bar, the blades being connected by a cord passing through pulleys on the ceiling, so that raising one lowers the other, or two iris diaphragms may be used, the same being connected by means of a light chain or cord running through pulleys on the ceiling, so that the opening of one closes the other.

Such an arrangement is awkward, because of necessity for reducing the current of both projection arcs, and because the projectionists must stand between the projectors and reach over to put the slides in the right hand carrier. We repeat, we do not advise it, but it can be done.

MATCHED LENSES.—The lenses of a dissolver must be so matched that each will project a picture exactly the same size. When ordering lenses for a dissolver the fact that they are for that use should be made clear and the dealer instructed to send matched lenses.

LENSES IN REGISTER.—It is necessary that the lenses of a dissolving stereopticon be so set that they will "register" accurately. By this it is meant that the light projected by each of them will occupy exactly the same space on the screen.

There are several ways of testing the register of the lenses, but the following will suffice. Select any stereopticon slide, place it in the carrier, the lower one if it is a regular dissolving stereopticon, and so adjust the lens that the picture registers where you want it on the screen. Either make a small mark on the screen at the two lower corners of the picture, or if it cannot be reached, then lean something against the screen so that its upper end will just touch the lower edge of the picture at one of the corners. Next place the **same slide** in the other carrier and adjust that lens until it registers in the same place. The important part of this is that the same slide be used in both carriers, because if different slides are used there might be a difference in size of opening in the mat.

For accurate registering the better way is to proceed as follows: Make two slides of tin or thin sheet metal, so that they will fit snugly in the carrier. Laying one over the other so that they accurately register with each other, punch a small hole near to and equidistant from each edge of the slide. Driving a shingle nail through will do. With an ordinary slide, so adjust the lower lens that the picture is where you want it on the screen, and so adjust the slide carrier that the picture on the screen is level, then place the metal slides in the carriers, being sure that matched holes are on the same side, and adjust upper lens and carrier so that the holes match on the screen.

HAVE PICTURE LEVEL.—It is essential that the carrier be so adjusted that the picture is level on the screen. This may be accomplished by raising one side of the carrier, blocking it up with some non-inflammable substance, first being sure that the dissolver, as a whole, sets perfectly level.

THE PICTURE.—Supplied with proper equipment, there is ordinarily no excuse for anything except perfect stereopticon projection. Yellow corners in the stereopticon picture, or a ghost in its center, are positive evidence of one of two things, viz.: the condensing system is not right, or the projectionist has not properly adjusted his light or his optical train.

THE REASON.—The stereopticon projection lens necessary to project a picture the same width as a moving picture at the same distance is of much longer E. F. than the M. P. projection lens is because the aperture of the slide (opening in mat) is very much larger, hence not nearly so much magnification is required, and the shorter E. F. of a lens the greater the magnification to a given distance.

THE PICTURE.—The stereopticon picture should not be too brilliant, and should present a clean, clear, sharp-cut appearance. Its size should of course be according to the size of the auditorium, but when used in conjunction with a motion picture entertainment, there is no necessity for a stereopticon picture which will have greater height than the motion picture. If the screen is bordered in black, or any other color for that matter, it is of course impractical to have a stereopticon picture the same width as the moving picture, because the proportions of the slide mat and the motion picture projector are different.

It seems to us that, as a matter of plain common sense, the standard slide mat opening proportions should be changed to match the proportions of the motion picture aperture, which would be a trifle less than 3x2.25 inches. This latter is the standard approved by the Society of Motion Picture Engineers, which should be accepted by slide makers and put into general use immediately.

DISSOLVING SLIDE CARRIER.—There is a slide carrier, made by Burke and James, Chicago, called the "Ingento," designed for use with a single stereopticon, which produces what its manufacturers claim to be a dissolving effect. This claim is not, however, strictly true, though the change of slides is made very quickly—so quickly that a fairly near approach is had to the dissolving effect. We can recommend this carrier for use with a single stereopticon. Its use with a dissolver presents no advantage whatever,

STEREOPTICON SLIDES.—Stereopticon slides consist of two pieces of very thin glass, each 3¼ inches by 4 inches, bound together with gummed paper binder strip. Between these glasses is a paper mask, known as the "mat," which serves to outline the photograph, limiting the area through which the light can pass.

The opening in the standard mat is 2¾ inches high, by 3 inches wide. Mat openings, however, vary in size, and in the shape of the opening, the one we have given the dimensions of (2¾x3 inches) being the standard usually used for advertising and song slides. See comments under "The Picture," page 808.

The photograph may or may not be colored. If it is, water colors are used, which are applied by hand process. The second piece of glass is merely a clear piece of glass, called a "cover glass," the only function of which is to protect the photograph.

Figure 313.

The side of the glass bearing the photograph should always be towards the light, since otherwise everything will be reversed, and any written or printed matter contained on the slide will read backwards. Usually the mat bears printing, or some ornamental design. In placing the mat in the slide, the printed or ornamental side of the mat should be away from the photograph, then if this side of the mat be always placed next the light there will be no possibility of having reading matter reversed, though this does not guard against getting the slide in wrong side up.

Slides are placed in the carrier bottom side up. If they are placed in right side up, the picture on the screen will be wrong side up.

Fig. 313 illustrates the mat side of a slide—the side which goes toward the light. In the lower left-hand corner is a black spot. This is known as the "thumb mark." It should always be in the lower left-hand corner as you hold the slide right side up, in the position as shown in Fig. 313. When placed in the carrier, this mark will be in the upper right-hand corner as you look towards the screen. With the mat in the right way, and the slides properly marked, as indicated in Fig. 313 (thumb mark in lower left-hand corner), there can be no excuse for getting a slide in the carrier wrong.

HANDLING SLIDES.—The projectionist who uses stereopticon slides should be very sure they are perfectly clean before he projects them. Every bit of dirt on the face of the slide will show on the screen, and we know of no one thing which so thoroughly advertises a sloppy, careless, slovenly workman as the imprint of his dirty fingers projected to the screen because they are carried on the face of a slide he was too lazy or to careless to clean.

Slides may be cleaned by breathing on them when cold, polishing quickly afterwards with a clean cloth, or by washing with a mixture of half and half water and denatured alcohol, polishing quickly afterwards.

In removing slides from the carrier, the average projectionist leaves the marks of his fingers thereon. This is because he does not handle them right. In placing a slide in the carrier it should be handled by its **thumb mark corner only.** In taking it out it should be raised slightly with the middle finger and then seized between the thumb and forefinger and removed as per Fig. 314. **Handled this way there will be no finger marks on the slides.**

CAUTION.—When using a single stereopticon, be very careful to ease the slide down into the carrier gently, so as not to cause the carrier to move. If the carrier moves, the picture on the screen will move. A rather ridiculous effect is produced when an audience is watching, for instance, a battleship, and due to the carelessness of the projectionist in placing the other slide in the carrier, the whole ship, ocean and all, jumps up in the air a couple of feet and settles back with a bump.

REPAIRING SLIDES.—In event a slide is broken, it may be made as good as new if the crack be in the cover glass only. In the event it is only necessary to remove the broken cover glass, substituting a new one, which has first been thoroughly cleaned, rebinding the slide as it was before. Gummed binder strip and cover glass may be obtained from any supply dealer. If, however, the crack is in the glass bearing the photograph, then the damage cannot be repaired. Where stereopticon slides are used, it is well that a few cover glass mats and some gummed binder strip be kept on hand in the projection room.

MAKING ADVERTISING SLIDES.—It is entirely practical to make slides designed to convey messages to the audience. There are many ways of doing this, some very simple and some rather complicated. The highest grade slides of this character are, of course, made by photography, and the most satisfactory results may be had by photographing white lettering on black cardboard. The cardboard may be any size desired, from 6½ inches high by 8 inches wide up to 2 feet wide. Any desired photograph may be attached to the card and surrounded with lettering. The white paint is made of dry white lead and thin glue, enough lead being used so that it is thick enough to cover well and not run. Being supplied with the advertising text matter, any competent sign painter can make the card, or with practice some one around the theatre may learn to do it very well, particularly if he obtains books of architect's alphabets to use as guides. The cards should be painted in the proportions of 3¼ inches by 4 inches—that is to say, the cards may be any

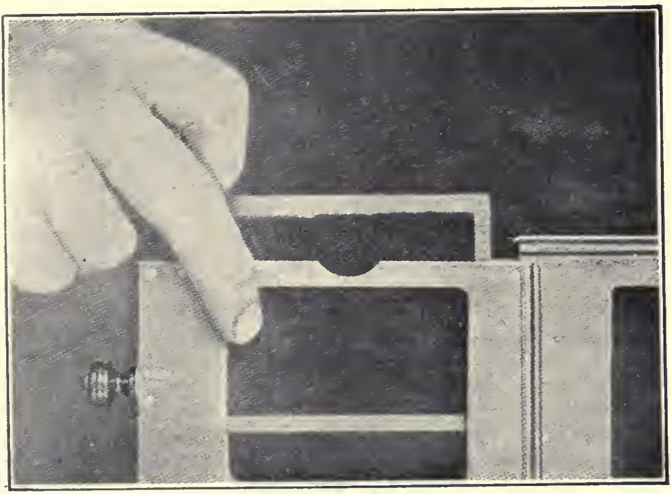


Figure 314.

size, but must be in those proportions. When finished the card is photographed in the usual way, and a positive print made on a slide plate, either by reduction, or by contact if the photograph is of slide size.

CAUTION.—In making the positive, remember that whereas the slide glass is 3¼ inches by 4 inches, the mat opening is much smaller, and that the positive print must include all lettering within the area covered by the mat opening.

If only one copy of a slide is needed it may be made by writing the desired matter on a white card, using black ink, and photographing the same. Before photographing, however, reverse the plate in the lens holder and stop the lens down to make up for the focus being thrown out by the reversal of the slide. The plate will develop with white letters on a black background, and will be readily finished, the same as a contact slide from a negative. Unless you reverse the plate everything, including reading matter, will be reversed on the screen.

It is also possible to write on perfectly clean cover glass by means of special inks, which may be had from supply dealers. It is also possible to write on transparent celluloid with India ink, and then print a photographic slide by contact. This latter method has the advantage of saving the expense of slide plate negative, and the celluloid, besides being low in cost, may be used over and over again, since the ink may be washed off.

It should be remembered, too, that a black background slide with white letters is very much easier on the eyes of the audience than is the white background with black letters.

When making photographic slides from celluloid, when the slide has been washed and fixed it should be set away to dry, and should not be moved during the drying process, since moving will cause unevenness of density.

A fairly acceptable advertising, or other announcement slide, may be made by typewriting on light yellow or clear gelatine, being very careful, however, that you do not get your fingers on the gelatine, because if you do the marks will show. The gelatine should then be bound up between clean cover glass, using a mat. The typewriter ribbon must be well inked, and the type letters clean, for good results.

Another way is to write on clean cover glass with special slide inks, which may be had from dealers. Another and very excellent way is to dissolve dry gum demar in turpentine, allowing it to stand until it settles. The correct proportion, by measurement, is one of dry demar to twenty of turpentine. The solution is very thin, but it does the trick. First clean the cover glass thoroughly, then hold it perfectly level and pour on some of the solution, allowing it to spread over the entire surface, after which the surplus may be drained back into the bottle from one of the corners, and coating allowed to dry. Glass thus treated may be written on with an ordinary pen and ink, just as one would write on paper. The drying process will require several hours, but the writing may be washed off with turpentine and the coating used many times. It is difficult to tell which is the coated side, therefore a permanent mark should be made on that side, or a small gummed sticker should be affixed to one corner.

Gelatine may also be used for coating, the process being the same as above, substituting for the demar coating one made by dissolving clear gelatine in hot water. The gelatine may be had from any grocery or drug store; the proportion is one measure of gelatine to ten of water. The coating is fairly satisfactory, but can only be used once. The solution should be passed through a very fine cloth before using.

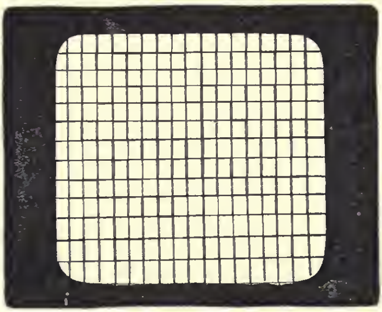


Figure 315.

The projectionist who has occasion to make written slides will find the following to be a great help. Get a board, either of basswood or clear, soft pine, about 12 inches square. On one surface paste a sheet of paper 6 by 8 inches square, and on this paper paste an ordinary slide mat, laying off the paper surface inside the mat checker-board fashion, with the lines about 3/16 of an inch apart both ways, as per Fig. 315. Lay the glass you purpose to write on over the slide mat, and on two sides tack strips of cardboard to help you hold it in place. The lines will then serve as a guide for your writing, enabling you to do a neat job.

Clean glass over which the tongue has been passed may be written on with ordinary ink after the saliva deposit has dried.

Another very satisfactory way is to coat cover glass with an opaque coating, such as may be made by thinning coach painter's black with turpentine, coating the glass and allowing it to dry, after which writing on the glass, using a sharp instrument, will produce clear letters with a perfectly opaque background. Coating cover glass with a solution of Bon Ami which may be had at any grocery store, and allowing it to dry, produces a similar result. The surface may be written on by using a sharp instrument.

In fact we could fill pages of the various methods of making advertising slides, but what has been said is, we believe, sufficient.

Mazda Lamp Projection

PROJECTION by means of an incandescent light source is no longer an experiment. Its practicability, within certain limits, has been very thoroughly established. Mazda lamp projection now is, and for a considerable time has been giving perfect satisfaction in a very large number of theatres.

In order to intelligently decide as to the advisability of substituting Mazda lamps for the arc lamp, it is necessary that the exhibitor and the projectionist have a good fundamental knowledge of the various things involved.

SOURCE BRIGHTNESS AND UTILIZATION OF LIGHT. —Let us first consider the possibilities of the two sources of light, from the view point of brilliancy per unit area, and the area of the light source itself.

The crater of the electric arc is the most brilliant source of artificial light evolved up to this time. This is because the floor of the crater of the electric arc is and must be raised to the temperature necessary to volatilize, or vaporize carbon, which is the hardest, most refractory substance known to science. The brilliancy per unit area of the ordinary projection arc crater (cored carbon) is between 132 and 160 candle power per square millimeter. What the brilliancy of the high intensity arc crater per unit of area is we do not yet know.

The Mazda light source cannot possibly equal the brilliancy per unit area of the electric crater, since the temperature necessary to produce such a result would instantly volatilize the lamp filament, and thus destroy the light source. In the Mazda lamp we therefore must be content with a light source much less brilliant, per unit area, than is the crater floor of the electric arc, but this is overcome to some extent by being able to locate it much nearer the lens.

Due to the relatively high brilliancy per unit area of the electric crater, it is not to be hoped that the Mazda lamp can or ever will furnish a screen illumination equal in brilliancy to that supplied by the high intensity electric arc. Just how nearly the Mazda lamp will be able to duplicate the performance of the arc is, however, a matter for future decision.

The problem of determining the possibilities with the Mazda lamp for motion picture projection purposes involves many things. First of all, there is the possibility that the condenser can be and will be supplanted by an ellipsoid reflector, or other means of condensing the light, or of utilizing the light from a source of larger area, which will very greatly increase the possible screen illumination supplied by a Mazda light source. When working with a condenser lens, however, the thing becomes very complicated. The principal reason for this is that the area of a light source is limited so far as present procedure goes, when that source must be projected through a small aperture by a condensing lens, and the beam again picked up by a second lens system (projection lens) beyond the aperture.

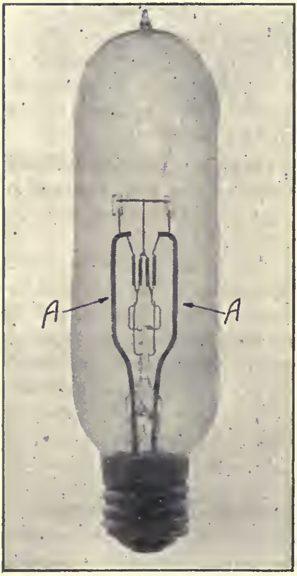


Figure 316.

Under conditions prevailing with the electric arc it has been impractical to use a light source of appreciably greater diameter than one half inch and the same limitation has thus far prevailed with the Mazda lamp, but with this difference: due to the difference in heat, the Mada light source may be, and is placed very much nearer a condenser lens than can be the crater of an electric arc of equal area, therefore the condenser will pick up a very much greater percentage of the total light (see Fig. 364, page 162) when working with the Mazda lamp than when working with an electric arc.

The use of a large projection lens diameter should, in theory, compel an increase in the width of the revolving shutter master-blade. That it does so may be disputed by some, because of the fact that many projectionists change from a small to a large diameter projection lens without any apparent necessity for altering the revolving shutter master-blade. This is true with the arc as well as with the Mazda lamp, but it in no way alters the truth of the proposition that the larger diameter lens requires a wider master blade than the smaller diameter lens. It simply means that the projectionist was using an unnecessary width of master-blade while using the smaller diameter lens. In other words, while using the small diameter lens he was using a master-blade wide enough for a large diameter lens, hence was working unintelligently and wastefully.

The foregoing may not sound very impressive, but it nevertheless is a fair statement of the main elements of the problems involved, when it comes to a comparison of the electric arc and the Mazda lamp as a motion picture projection light source.

Since the Mazda lamp filament is in fixed position, a glass mirror reflector, spherical in form, is placed behind it,

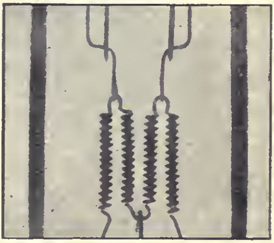


Figure 317.

Figure 318.

which reflects through the spaces between the filament coils a large percentage of the light which would otherwise not reach the condenser, and hence would be wasted.

THE MAZDA MOTION PICTURE PROJECTOR LAMP.— In Fig. 316 we see one of the latest Mazda motion picture projector lamps illustrated, and in Fig. 317 we see the filament thereof at exactly full size. A A, Fig. 316 are the supports for the filament, which supports are current carrying and of opposite polarity.

The support of the filament has been one of the most serious problems encountered by Mazda lamp engineers. The reason this point has caused so much trouble and vexatious delay in the perfection of the Mazda projector lamp is that the four coils must be held perfectly straight, so that as a whole, they present an even, flat surface to the collector lens. This seemingly simple thing proved to be an exceedingly difficult problem, because of the fact that the filament is subjected to very heavy expansion under the high temperature at which it must operate, contracting to normal length again when it cools off. This alternate expansion and contraction occurs frequently, every time the lamp is started or stopped, hence unless the coils be supported in precisely the right way they are likely to sag, warp or partially short-circuit, as shown in Fig. 318. If this occurs it of course either entirely ruins the lamp or else very greatly impairs its efficiency, depending on how great the fault may be in the individual case.

Mazda lamp engineers have finally, however, pretty well solved the problem, and a filament is now used which is of such composition and has such support that it is very dependable. True, an occasional coil still will fail, and probably always will, but they are few, and the lamps are guaranteed, within certain limits against such failure.

Figure 319.

HOW THE MAZDA LIGHT SOURCE IS MADE UP.—The Mazda motion picture projector lamp light source is composed of four coils of tungsten wire. These coils are wound exactly the same as are ordinary coil springs, or rheostat coils. Their exact size and length may be seen in Fig. 317. The base of the metal used is either a pure, or very nearly pure tungsten.

As will be seen by examining Fig. 317, the coils are separated from each other by a distance equal to a little less than their own diameter, and the four coils, as a whole, are so suspended and held that they present a perfectly flat surface to the face of the collector lens.

From the foregoing it will be understood that the Mazda

Figure 319½.

lamp is a light source, which does not, and cannot in itself present a solid, unbroken surface. Instead, it, of itself, presents the surface shown in Fig. 319. This fault is, however, in very great measure overcome by means of an image of the coils, which is reflected by a spherical mirror so placed (see Fig. 327) that it not only reflects, but also focuses an image of the coils between the coils themselves, as per Fig. 320. The image of the coils should be made the same size as the coils themselves, so that the image completely fills the space between the coils, and overlaps on the coils very slightly. This for all practical purposes presents to the collector a solid, unbroken light source, and while it is true that the image of the coils is, both in theory and fact, somewhat less brilliant than the coils themselves, still the difference is so slight that it is, to all intents and purposes, non-existent.

SHORT CIRCUITING IN COILS.—Reverting, let us again examine Fig. 318, which shows a very bad case of filament distortion. It is an abnormal case, only shown to illustrate what Mazda engineers had to contend with in evolving a support for the lamp filament which would prevent this trouble. Such a case will probably never be found in the modern lamp. The dark spots in the filament, Fig. 318, indicate short circuited turns of the coils, or, in other words, places where adjoining spirals of the coil touch each other, so that

Figure 320.

the current jumps across, instead of traveling around the spiral. This fault also is extremely unlikely to occur in the later type lamp, but it does sometimes happen, and a dark spot in a coil is evidence of such short-circuiting.

It is, or should be, needless to tell you that in case a lamp filament does warp, distort or sag to any considerable extent the lamp should immediately be discarded, if for no other reason than because you can no longer focus the image of the coils entirely between the coils, which fault will result in a "streaky" screen.

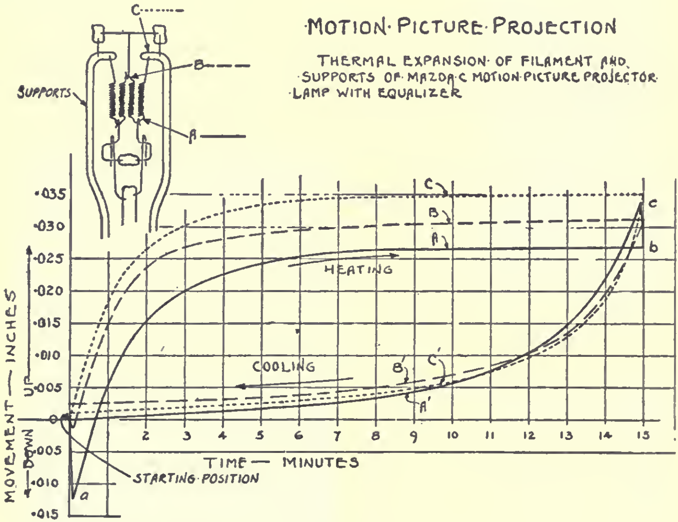


Figure 321.

In Fig. 321 we have a chart provided by the G. E. Company, designed to show the action of the filament under expansion and contraction. The filament has very high resistance, therefore when the current is turned on it heats up almost instantaneously. This is graphically illustrated by curves in Fig 321, in which the curve lines show the thermal expansion of the standard commercial filament, as now constructed.

As you may see by examining Fig. 317, the filament is suspended from above. Further examination of Fig. 317 will show you that when heat is applied, any elongation of the filament, as a whole, must and will be downward, because the construction of its support is such that the coils are left free to expand downward, whereas the support from above is rigid. Not all the lower part of the support is shown in Fig. 317, but it is shown very clearly in the drawing in Fig. 321. It consists of two long hooks which engage a wide loop in such way that the loop may slide up and down in the hooks.

In Fig. 321 the horizontal row of figures represents time in minutes, and the vertical row represents expansion of the coils in fractions of an inch. The upper curve lines represent expansion while filament is heating, and the lower lines contraction while the filament is cooling off. It is read thus. Suppose we draw a line straight up from 2 minutes in the horizontal row of figures, until it strikes the upper solid black line, and from there draw a horizontal line over to the vertical row of figures. We shall find it to strike the figure .015, therefore, since the solid black line represents the movement of the lower end of the filament under the influence of expansion, we see that at the end of two minutes after turning current on the cold filament, the lower end of the filament has moved .015 of an inch. The action of other points are read in the same way. You will observe that the total expansion and contraction reaches the surprising distance of almost .035 of an inch, but that this is not altogether in the filament itself, the actual filament expansion being represented in the difference between lines A (solid black) and B, (broken line), the rest being in the supports.

In reading the scale, the dotted line, the broken line and the solid line represent respectively the expansion and contraction of the top of the supports, the top of the filament and the bottom of the filament.

BLACKENING OF THE BULB.—As the age of a Mazda lamp increases, a deposit will form on the interior of the globe, which gradually causes a blackening of the glass. This is caused by what might be termed evaporation of the tungsten filament. The principle reason for making the Mazda projector lamp globe tall is to provide room above the filament, as it has been found that this deposit will invariably be made on the upper part of the globe, hence

With a tall globe the blackening of the glass is almost entirely above the plane of the filament. The blackening

which may occur at the plane of the filament is of such comparatively slight amount that it does not decrease the illumination of the lamp to any appreciable extent, if at all.

The reason we say "if at all" is that, since the Mazda projector lamp is operated at constant current (amperage) instead of constant voltage, as is the case with the ordinary incandescent lamp, as the diameter of the filament is decreased by use, the lamp works at higher efficiency, hence gives off a sufficiently higher illumination to either entirely compensate for any blackening, or even more than compensate for it.

Figure 322.

The General Electric Company claims that, by actual tests during the life of a lamp, the total light flux of the lamp is increased by from two to five per cent., always provided the filament itself remain in otherwise perfect condition—does not warp, distort or sag. If the filament be warped, then while the total light-giving power may not be affected, still the light delivered to the screen will inevitably be decreased because of the impossibility of focusing the filament images between the coils, and thus securing an even, unbroken light source.

A Mazda motion picture projector lamp should seldom be discarded because of blackening of the bulb. Usually the only reason justifying the discarding of a lamp which is still in working order is the bad warping, sagging or distortion of the filament, or other fault in the filament itself, such as short circuiting of some portion of the individual coils.

QUALITY OF LIGHT.—There is a very decided difference in the tone of the light from the electric arc crater and from the Mazda lamp. Light from the electric crater is a clear. more or less bluish white, somewhat harsh and very brilliant light. Light from a Mazda lamp has, by comparison, a very much more mellow tone. To the ordinary eye it is, by contrast, a yellowish white. This operates in two ways. The light from the arc is, by reason of its bluish whiteness, very penetrating. The bluish whiteness of the light has the effect, especially at high amperage, of causing the white in the screen image to appear more or less chalky and unnatural. This the light from the Mazda lamp does not do. It gives to the screen image a more natural appearance, and the more mellow tone of the light is more restful to the eye. This is, however, qualified by the fact that if the screen illumination be of too low intensity there may be eye-strain induced through difficulty in discerning detail in the image.

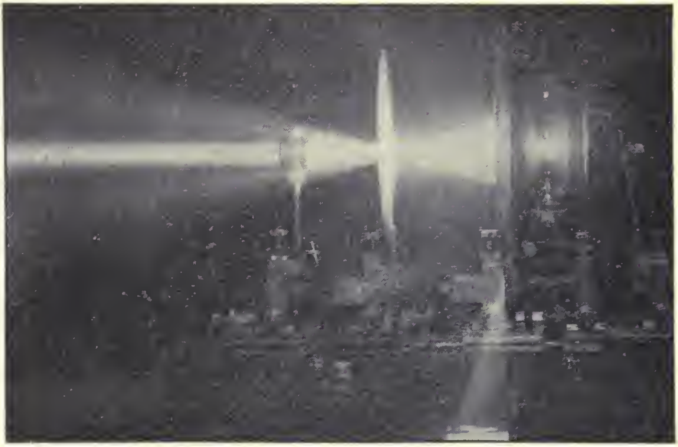


Figure 323.

In Fig. 323 we may see the reason for using a large diameter projection lens. A laboratory Mazda lamp set up is shown, using a prismatic condenser, such as we see in Fig. 322. The prismatic condenser compels a very short distance between condenser and aperture, with a correspondingly wide divergence of the light beam on the projection lens side of the projector aperture, as shown. The possibility for loss of light through this condition and a small diameter projection lens may be understood by examining Figs. 46 to 57, pages 181 to 193.

In Fig. 324 we have the same identical set-up as in Fig. 323, except that whereas a small diameter projection lens is used in Fig. 323, a lens of large diameter is substituted in Fig. 324, which eliminates nearly all the light loss because the wider diameter enables the lens to pick up nearly the entire beam. The print (Fig. 324) shows no light loss at all, but the original photograph shows that even the large diameter lens fails to cover the entire beam, so that there is still quite a bit of loss.

In Figs. 325 and 326 we have the same identical set-up, insofar as concerns distance of projection lens, but instead of the prismatic condenser there is the regulation 2-lens plano convex combination ordinarily employed where an arc light source is used. This, you will observe, because of the

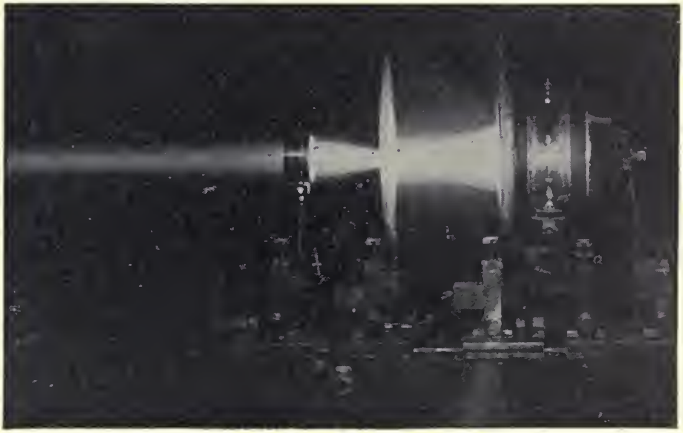


Figure 324.

greater distance from condenser to aperture, enables the smaller projection lens to pick up nearly all the light.

Again the print shows no loss, Fig. 325, but the original photograph did show some loss. The larger lens, Fig. 326, covers the entire beam. On the other hand, however, there is loss of light between the two condenser lenses and an additional reflection and absorption loss of about 12 per cent. in the added lens; also the light source is located a decidedly greater distance from the face of the collector lens than it is in the case of the prismatic lens. Exactly what the possibilities in light loss and other things as between the two systems may be we are unable to say. The thing is altogether too complicated, and we could not undertake to advise you on that point. It is to be observed, however, that there are a great many more installations of prismatic than of plano convex, which may or may not indicate superiority for the prismatic.

RELATIVE LIGHT TRANSMITTING POWERS.—Tests made by the engineering department of the General Electric Company as to the light transmitting power of small and large diameter projection lenses, commercially known as No. 1 and No. 2 lenses, show that, working without a projector revolving shutter the large diameter lens transmits double the light flux transmitted by the small diameter lens. This, however, only holds good where distance between con-

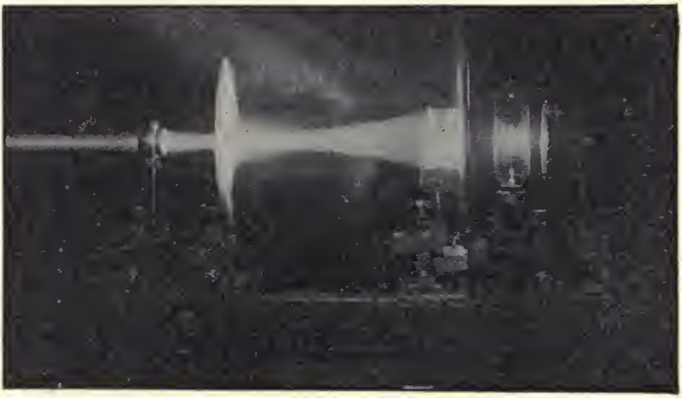


Figure 325.

denser and aperture is short, as where the prismatic condenser is used. Both the prismatic and plano convex systems have advocates, and both have advantages and disadvantages. We do not care to take sides. The thing has too many complications. Examine the merits and demerits of the two systems for yourself. It is one matter on which we do not, at least as yet, care to offer advice.

Remember this, however, if a prismatic condenser be used on a combination projector (M. P. projector with stereo attachment), it will be necessary to have a separate set of plano convex condensers for the stereopticon, which same may, however, be used for motion picture projection at any time, if it is so desired.

CONTROL APPARATUS.—The Mazda motion picture projector lamp filament must, in order to secure maximum screen illumination, be operated constantly at the full labeled capacity of the lamp. The instant the amperage drops below the labeled capacity of the lamp the screen illumination is decreased, and the decrease is very rapid. At 28 amperes, for instance, the screen illumination from a 30 ampere lamp drops to about 73 per cent. normal, and at 33 amperes it rises to about 160 per cent.

From this the projectionist can see the vital importance of operating the lamp constantly at its maximum labeled amperage of 30, carefully remembering, however, that while it is possible to operate it beyond its labeled capacity, and thus

Figure 326.

secure a very much higher screen illumination, it will very greatly shorten the life of the lamp.

The amperage at the lamp should be under the control of the projectionist. Where the supply is A. C. this is accomplished by means of a specially constructed transformer, known as the "Regulator." These devices are made both automatic and for hand control. The automatic is opposed by many, on the ground that when the current is first turned on there is an instantaneous and rather heavy surge of current, which for the fraction of a second very heavily overloads the lamp filament. Further objection to the automatic is that when it is employed the projectionist has no control at all over the light producing power of the lamp.

With the hand controlled regulator the amperage at the lamp is entirely within the control of the projectionist. We recommend to you the hand regulator as best, except in cases where the current supply is subject to very heavy and constant fluctuations in voltage.

Another advantage of the hand controlled regulator is that whereas with the automatic regulator the filament of the lamp is heated up at full load immediately, with the hand regulator it may be, should be, and by the careful projectionist is brought up to maximum operating temperature gradually. The same reasoning applies to cooling the filament when shutting off the lamp. Still another advantage

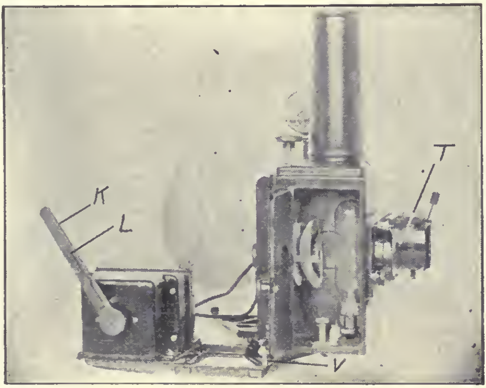


Figure 327.

of the hand regulator is that it is small, compact and may be mounted on the projector, where it should be, whereas in general the automatic regulator is bulky, and not so well adapted for mounting on the projector.

One of the most essential features in successful motion picture projection is the combining of regulator, lamphouse and ammeter into a single unit, placed on the projector, where it is right under the eye and hand of the projectionist.

GENERAL ELECTRIC COMPANY REGULATORS.—The General Electric Company manufactures three forms of hand controlled regulators for Mazda lamps operating direct from A. C. lines. Each of these devices is mounted on the same base as the projector Mazda lamphouse.

The type HDS Form E, Figs. 327, 328, 329 and 329½, hand controlled regulator is a straight transformer, wound and especially made for the regulation of amperage for the 30 ampere, 900 watt Mazda C motion picture projector lamp, for supply voltages from 75 to 250 and frequencies from 25 to 60. This type regulator has, according to manufacturer's claim, an efficiency of 90 per cent.

To Operate the regulator move lever K, Figs, 327, 328 and 329 toward the lamphouse (clockwise) until pin M, Figs. 328 and 329, strikes stop N, Fig. 328. With lever K in this position contact fingers H, Fig. 329, is on warming contact F, Figs. 329 and 329½, which connects with coil D, Figs. 329 and 329½, through which the current must pass. Coil D is the warming reactance, or choke coil. It acts to prevent a sudden rush of current through the lamp filament at the start, supplying, as it does, only sufficient current to bring the filament to a glow.

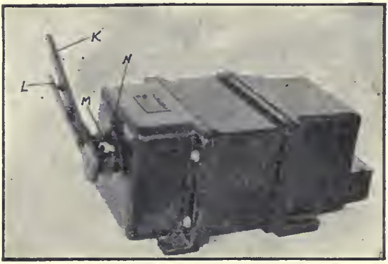


Figure 328.

If auxiliary lever L. Figs. 327, 328 and 329, be now shoved in, thus releasing stop pin M, and lever K be shoved further over toward the lamphouse, contact fingers H-H, Fig. 329 will successfully make contact with point G-G-G-G-G, Fig. 329, which has the effect of allowing more current to reach the lamp.

Contact reactance C, Figs. 329 and 329½, acts to prevent a momentary drop in illumination as the contact fingers move from one point to the next.

To Shut off Current it is only necessary to move lever L backward, away from the lamphouse. This opens the circuit on the primary side of the transformer.

In Fig. 329, A indicates the line leads and B the lamp leads. In other words you connect from contacts A to the line, and from contacts B to the lamp.

Type HMC, Form B, hand controlled regulator, illustrated in Figs. 330, 331 and 332, varies the amount of current supply to the lamp filament by magnetic action. It is made for use with the 30 ampere, 900 watt Mazda motion picture projector lamp, and is designed for use on voltage from 100 to 125 and 200 to 250 and on frequencies from 25 to 60.

To Operate move the control lever L, Figs. 330 and 331, towards lamphouse until click of switch F, Figs. 331 and 332, is heard. Armature E, Fig. 331, then shunts the magnetic flux from secondary coil D, Figs. 331 and 332, so that only a small amount of current passes through the lamp filament. As lever L is moved further toward the lamphouse, armature E, Fig. 331, attached to lever L, and therefore rotating with

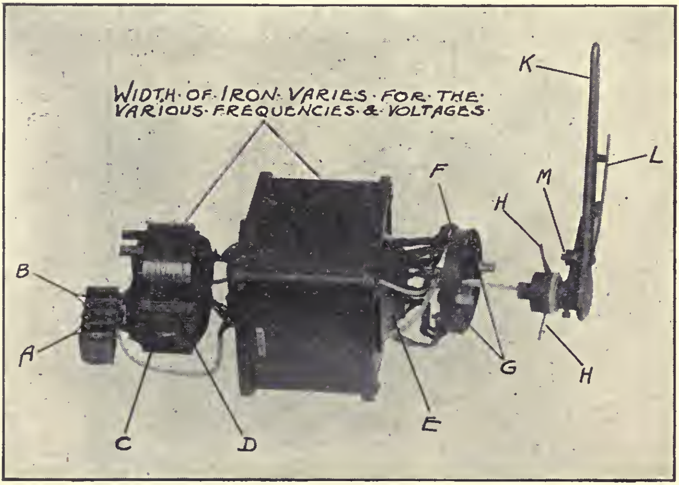


Figure 329.

it, increases the air gap and decreases the amount of shunted flux through it, the effect of this being to increase the current flow through the lamp filament.

To shut off the current it is only necessary to move lever L away from the lamphouse, which rotates armature E until it trips pin G, Figs. 331 and 332, thus opening switch F, Figs. 331 and 332, which will cause a clicking sound.

In Figs. 331 and 332, A denotes location of line, and B of lamp leads.

Type HMC, Form A, hand controlled regulator, illustrated in Figs, 333, 334 and 335, varies the current strength magnetically, and is designed for use with the 20 ampere, 600 watt lamp.

To Operate, turn on snap switch H, Figs. 333, 334 and 335, making sure that pointer on knob L, Figs. 333 and 334, is at the "low" position. Armature D, Fig. 334, will then be inside coil C, Figs. 334 and 335, and in this position it shunts the magnetic flux. As knob L, Figs. 333 and 334, is turned in a counter clockwise (to the left) direction, armature D is withdrawn from coil C, Figs. 334 and 335, which causes it to shunt

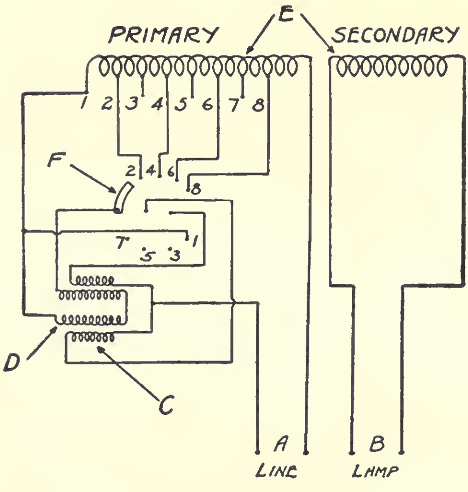


DIAGRAM OF CONNECTIONS TYPE H.D.S. FORM F GENERAL ELECTRIC COMPANY CURRENT REGULATOR

Figure 329½.

less flux, which has the effect of increasing current flow through secondary coil G, Figs. 334 and 335. In Fig. 334, E is an auto-transformer, F being the primary and G the secondary winding. A-A are the line and B-B the lamp leads.

To Shut off Current, turn knob L, Fig. 333, clockwise (to the right) to "Low" point and then open the switch.

AUTOMATIC REGULATOR.—The General Electric Co. also makes an automatic regulator called the Constant Current Regulator, Type RM. This is illustrated in Fig. 336 and its windings in 337. It is for use with the 30 ampere, 900 watt lamp, and has a regulation of 1 per cent., with (manufacturer's statement) an efficiency of 85 to 95 per cent.

To Operate, separate the two coils of the auto-transformer, Figs. 336 and 337. Then throw in the line switch, after which let the two coils come together gradually until the moving coil floats freely. To turn off the current, separate the coils, pull switch and then move coils together again. The balancing weight has ball bearings, to insure freedom of movement.

SYNCHRONOUS CONVERTER—To take care of the D. C. situation the General Electric Company puts out the "synchronous converter," shown in Fig. 338. The motor re-

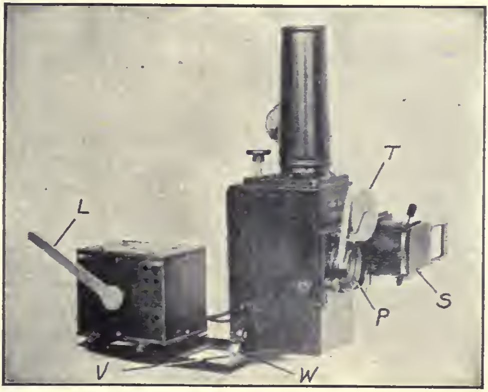


Figure 330.

ceives D. C. from the lines and delivers A. C. at about 25 cycles to the lamp. This seems peculiar, because whereas in arc lamp projection we go to heavy expense to convert A. C. into D. C., in Mazda the reverse is true, and for best results we convert D. C. back into A. C.

The synchronous converter has sufficient capacity to take care of the Mazda light source for two projectors. It is nothing more or less than a small synchronous converter connected up opposite to the way the synchronous converter is usually hooked up. It delivers A. C. at about 78 volts. It is about two feet in length, stands about one foot high and weighs something like 75 pounds. Its general care is covered under general instructions on motor generators, see Pages 444 to 461.

REGULATOR NECESSARY.—Let it be clearly understood that a regulator is necessary where a synchronous converter is used, but in this case a special regulator will be required, because the converter delivers current at lower voltage than the voltage of power lines.

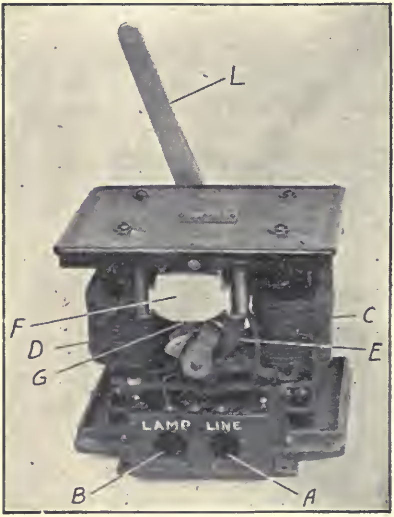


Figure 331.

RHEOSTATIC CONTROL.—In general, D. C. Mazda lamp installations using rheostatic resistance are not recommended. True, many of these installations have been made, and have given satisfaction to the exhibitor. They are not, however, recommended by lamp manufacturers, nor do we recommend them. The manufacturer will make such an installation if it is demanded, but for many reasons they recommend the synchronous converter, which, aside from first cost of installation, is much more efficient in operation than is rheostatic control.

HALLBERG REGULATOR.—J. H. Hallberg manufactures an automatic regulator for A. C. Mazda projector lamp installations, called the "Hallberg A. C. 4 in 1 Mazda Lamp Regulator." It is illustrated in Fig. 339. This regulator is constructed upon the constant current transformer principle. The secondary coil is stationary, while the primary coil is movable on a vertical central core This coil is supported so as to be adjusted to the correct position on the core for each particular lamp, and any change in current strength over that for which the transformer is set causes the primary coil to automatically alter its distance from the secondary coil. It will therefore be seen that current changes at the lamp filament will of necessity be very small.

The device is supplied with an ammeter, and there is a conveniently located arrangement for adjusting the coils, or "setting" the coils for any desired current value within range of the apparatus.

The Hallberg 4 in 1 is well made, and a good instrument of its kind.

USING THE LAMP SETTER.—For the purpose of mounting the Mazda projector lamp in socket the General Electric Company puts out what is known as a "lamp setter," illus-

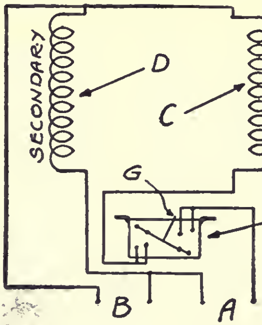


DIAGRAM OF CONNECTIONS TYPE HMC FORM B GENERAL ELECTRIC COMPANY CURRENT REGULATOR

Figure 332.

trated in Fig. 340. By the use of this setter it is possible to mount the lamp in its socket in such a way that an old lamp may be pulled out of the lamphouse and a new one installed, with every assurance that the filament of the new lamp will occupy precisely the same place with relation to the optical axis and the lens as did the old one; also the filament will be square with the face of the collector lens. To use the lamp setter, proceed as follows

(A) Unscrew large nickel-head screw A, Figs. 340 and 341, until it is backed out ⅜ to 7/16 of an inch.

(B) Loosen small clamp screws B-B, Figs 340 and 341, on lamp socket.

(C) Unscrew center contact C, Fig. 341, until it is flush with bottom of socket base.

(D) Insert lamp in socket, being sure to push it all the way down, at the same time making sure that the upper half of socket D-D, Figs. 340 and 341, moves freely in all directions, and that the lamp does not bind.

(E) Unscrew two large knurled screws, E-E, Fig. 340, E, Fig. 342, and E, Fig. 343, and open gate F as shown in Fig. 340.

(F) Insert socket, with lamp in place therein, in lamp setter, and close gate F, Fig. 340.

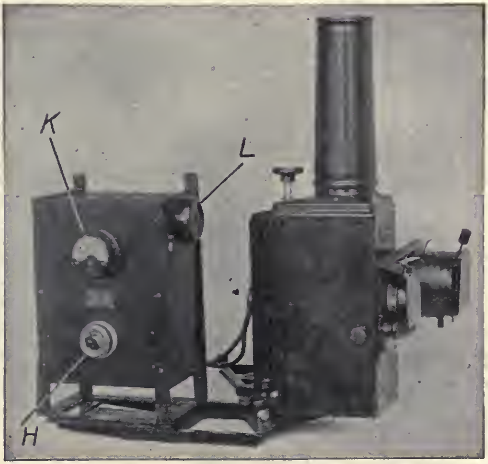


Figure 333.

(G) Turn lamp in its socket until edges of filament are parallel with notch G, Fig. 342, and with the notch on opposite side of setter.

(H) Look through sight holes H-H, Fig. 343, and raise lamp in center by screwing up on center contact from the bottom, as per Fig. 344, until bottom of filament coils is flush with lower edge of sight holes, as per Fig. 343.

(I) According to which is necessary, tighten or loosen knurled adjusting screws E, Fig. 343, until the point of the two pins in bottom of sight holes come exactly between the two center coils of the filament when you sight through the sight holes.

(J) Should the filament not now be vertical, screw in or out, as the case may require, screw A, Figs. 340, 341 and 342, until filament is vertical, after which repeat operation I.

(K) Tighten or loosen knurled head screw E, Figs. 340 and 342, until the filament is in line with the two notches in gate, as per Fig. 342. This is the focusing adjustment. It locates the filament the correct distance from face of collector lens.

(L) Check vertical (height of lamp) lateral (location of pins between center coils of filament) and focusing (distance from lens position) adjustments and be sure you have them EXACTLY right.

(M) Tighten socket clamp D-D, Fig. 341, by screwing up socket clamp screws B-B, Figs. 340 and 341, as shown in Fig. 345, thus locking the lamp in place in its socket.

(N) Gently tighten up on center socket contact C, Fig. 341, as shown in Fig. 344, until it makes firm contact with base of lamp. This latter is important in order to secure good contact and prevent possible arc between lamp and socket. Be careful, however, and do not tighten the screw too tight, and thus force the lamp out of alignment in socket.

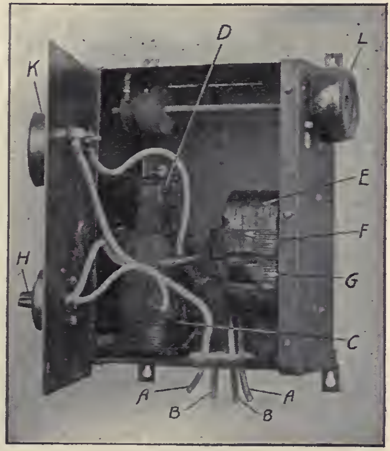


Figure 334.

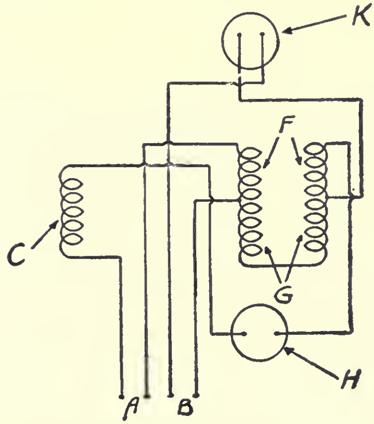
(O) Open gate F, Fig. 340, and unscrew knurled head screws E-E, Fig. 340, until they do not touch the lamp.

(P) Check lateral adjustment, and if found wrong, correct same by tightening or loosening nickel-head screw A, Figs. 340 and 341.

(Q) Lamp and socket may now be removed from lamp setter, and may be inserted in base K, Fig. 346, with full assurance that if the various steps in the process (which is not at all complicated, once you learn it) have been faithfully and correctly followed, the lamp will be exactly in correct position for projection without further adjustment.

ALIGNMENT.—TO SECURE MAXIMUM SCREEN ILLUMINATION, IT IS ABSOLUTELY NECESSARY THAT THE CENTER OF LAMP FILAMENT, CENTER OF APERTURE AND CENTER OF PROJECTION LENS BE EXACTLY ON THE OPTICAL AXIS OF THE SYSTEM.

CAUTION.—This is of very great importance with all Mazda projector lamp outfits because if any one of the elements named have its center even so much as 1/16 of



·DIAGRAM·OF·CONNECTIONS·TYPE·H·M·C·
·FORM·A·GENERAL·ELECTRIC·COMPANY·
·CURRENT·REGULATOR·

Figure 335.

an inch off the optical axis the screen illumination will be very greatly reduced.

To align the elements, first light the lamp and then open the dowser. Raise the automatic fire shutter or open the projector gate and turn projector fly-wheel until revolving shutter has opened the lens. Be sure lamphouse is all the way over against stop V, Figs. 327 and 330, in position for projecting motion pictures.

Move the whole carriage Q, Fig. 347, carrying the regulator and lamphouse forward until the front surface of the prismatic condenser is 6.5 inches from the aperture as per Fig.

351, except where state laws require a greater distance. Have a piece of dark colored, low reflecting cardboard held in front of the projection lens, at a distance therefrom which will sharply focus the rings of the condensing lens. Loosen wing nuts Z-Z-Z-Z, Fig. 347 (four of them) and raise or lower the lamphouse until the same number of rings show, up and down, in the image on the cardboard, as per B, Fig. 348. In other words, the image of the condenser is exactly centered up and down. Tighten wing nuts Z-Z-Z-Z firmly when done.

Next move lamphouse sidewise on its tracks until the same number of rings show sidewise in the image on the cardboard, as per D, Fig. 348, first, however, making certain that condenser holder is shoved clear over against its stop S, Fig. 350. The lamphouse may then be moved sidewise by screwing or unscrewing the nickle-head screw W, Fig. 347. This screw must be against stop V when the job is done. Screw W must then be locked by set screw J, Fig. 347. This completes the centering of the condenser with the optical axis.

Figure 336.

ADJUSTING FILAMENT OF LAMP ON OPTICAL AXIS.—It is of the very greatest importance imaginable that the center of the lamp filament be exactly on the optical axis of the optical train of the projector. Once a lamp has been adjusted in its socket in the lamp setter, as per instructions already given, and the filament has been centered on the optical axis, as per instructions we shall now give, all lamps thereafter adjusted **in the same lamp setter** will require no further adjustment, unless the adjustment become in some way altered, which should not happen in ordinary routine of work.

To center a lamp which has been previously properly adjusted in the lamp setter (always adjust lamp in lamp setter before you proceed with the following instructions, because if you did not, your work would all be for nothing), proceed as follows:

(A) Insert a lamp, previously adjusted in lamp setter as

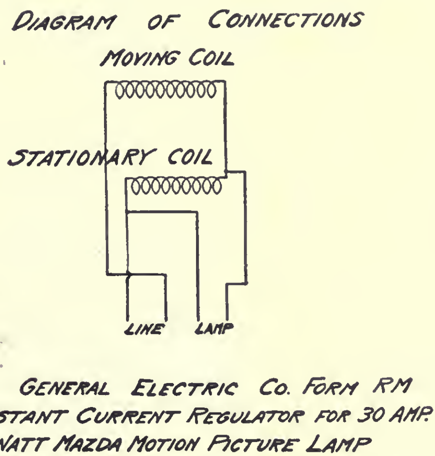


Figure 337.

per former instructions, in base K, Fig. 346, and shove it in as far as it will go.

(B) When focusing, or adjusting a lamp for the first time, loosen mirror clamping knob X, Fig. 347, and tip mirror either up or down by means of handle Y, Fig. 347.

(C) Place revolving shutter of projector from ½ to 1 inch from front end of projection lens barrel.

(D) See that primsatic condenser lens is in proper position for projection and pull lamphouse over against stop V, Fig. 347.

(E) Open dowser and either the automatic fire shutter or the projector mechanism gate.

(F) Light the lamp.

(G) Adjust projection lens so that edges of aperture are sharply focused on screen.

(H) Set revolving shutter in such position that light beam falls on one of its blades, as per Fig. 349. The filament image will not necessarily be sharp.

(I) Shove in or pull out the lamp socket by means of the small lateral adjustment screw L, on contact base K, Fig. 346, until the two center coils of the filament are exactly in center of lighted spot on shutter blade.

IMPORTANT.—Do not touch large nickeled screw A, Fig. 350, on lamp socket.

(J) Loosen socket base clamp T, Fig. 350, on steel plate carrying contact base, and move lamp forward and back until you get the smallest possible spot of light on aperture of projector, or until screen is brightest, though the screen will not at this stage of the proceedings be evenly illuminated. After this is done, tighten clamp screw T, Fig. 350. The distance of the filament from face of condenser will be found to be between 2⅛ and 2¼ inches, as per Fig. 350.

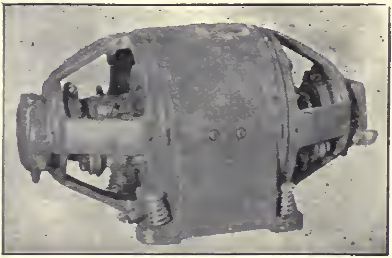


Figure 338.

(K) Test matter of filament being in center of spot on shutter blade. If too far to left screw in lateral adjustment screw L, Fig. 346, and shove lamp base further into its holder. If too far to right, reverse the procedure. If all directions have been faithfully followed the light should now be correctly centered on the projector aperture. If when filament image is in center of spot on shutter blade and spot at aperture of projector is out of center, then you have made some mistake and must do the whole job over again. But be certain the two center filament coil images are in center of spot on shutter. When lamp is properly set, lateral adjustment stop N, Fig. 350, above small screw K on contact base should firmly touch nickle screw A, Fig. 350, on lamp socket. Contact base is now properly set with respect to the lamp setter, and should require no further adjustment, but be sure the condenser slide and housing (these have to do with prismatic condensers only) are in correct position.

IMPORTANT.—The lamphouse, the condenser and the lamp setter are now adjusted with relation to each other, so that all lamps adjusted in the individual lamp setter used should be, and will be in correct position when placed in the lamphouse. One lamp setter is suffcient for a number of projectors. It should be clearly understood that **the same lamp setter must be used for a lamphouse all the time, or if another setter be used, then the lamphouse will have to be readjusted to center the filament of the new lamp on the optical axis.**

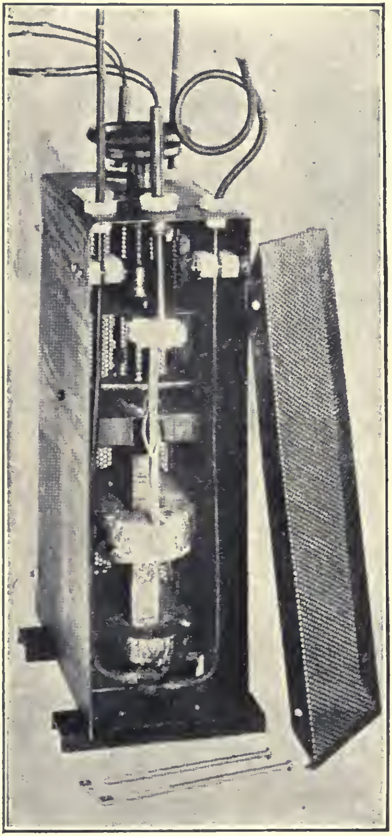


Figure 339.

(L) Close dowser T, Fig. 330, in the center of which is a pin hole, whereupon an image of the filament will be projected through the pin hole and will be clearly defined on the automatic fire shutter.

CAUTION.—The pin hole must not be used in focusing the condensing lens or aligning lamp filament. It is only designed to serve as a method of checking the placing of the mirror with reference to the filament.

The image projected through the pin hole will not necessarily be centered on the aperture, and the fact that it is off center with the aperture does not indicate that the line up of the condenser and lamp filament is incorrect. Next move the mirror by means of knob Y, Fig. 347. By turning the knob clockwise, the mirror image is made smaller and vice versa. This adjustment should be so made that the mirror image of the filament coils and the image of the filament coils are of exactly the same size. The mirror must now be so adjusted that the mirror image of the coils falls between the coils themselves, as per Fig. 320, whereupon the mirror must be

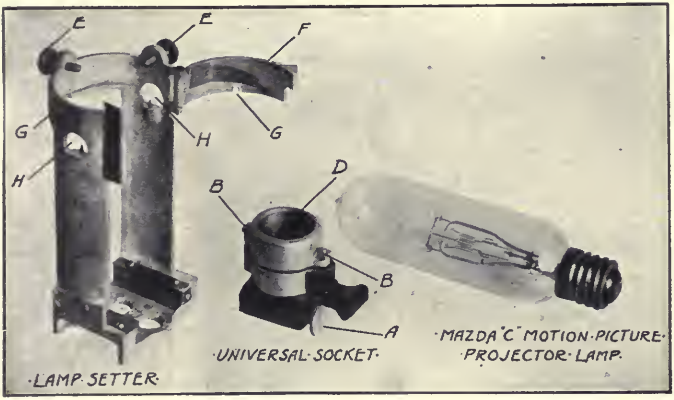


Figure 340.

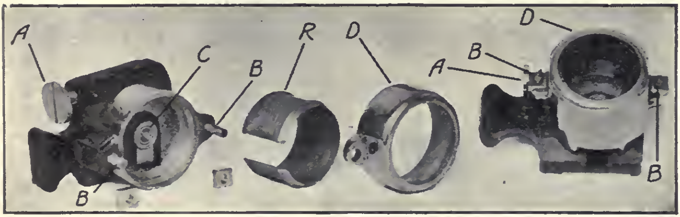


Figure 341.

locked rigidly in place by tightening knob, Fig. 347. Unless this adjustment be made right, the screen will be streaked vertically.

With the mirror correctly set, it should never be necessary to change it; though its adjustment should be checked from time to time to make sure that it is in correct position. This the projectionist may observe at any time by glancing at the automatic fire shutter when the dowser is closed. It may also be observed on the revolving shutter while the projector is in operation.

If when a new lamp is installed, the mirror images do not fall exactly between the filament images, move the mirror slightly one way or the other until the fault is remedied, but do not touch the lamp socket, or the adjusting contact screw N, Fig. 350.

Figure 342.

IMPORTANT.—Never use anything except lever K and L, Fig. 347, to start up the lamp, or to turn it off. If you leave controller lever K at "on," and pull the projector table switch, you will put the lamp out all right, and you may put it out of business for good, too.

ADVANTAGES OF MAZDA LAMP PROJECTION.— The main advantage in Mazda lamp projection is economy of operation. We can illustrate this advantage by comparison. Let us assume it is proposed to install Mazda lamp projection in a theatre using 35 ampere D. C. arcs. This is not extreme because it is very generally conceded that the Mazda lamp can succesfully replace carbon arcs of much higher amperage. Let us assume that the voltage of the arc is 55, under which condition we would have 55 × 35 = 1,925 watts consumed in the arc itself. This does not, however, represent the total consumption of the installation, since the line voltage, which may be 110 or higher, must be reduced to the arc voltage, or in other words to about 55 volts. The most efficient method of doing this, and at the same time delivering the necessary amperage at the arc, is by means of a motor generator, and these ma-

Figure 343.

chines cannot be expected to operate at greater than 70 per cent. efficiency. As a matter of fact, a motor generator set usually operates at decidedly less than this, particularly after they have been used for a while. It therefore follows that the 1,925 watts consumed by the arc represents but 70 per cent. of the total power consumed, which would be 2,751 watts.

On the other hand, the Mazda lamp equipment with which it is proposed to replace this installation would consist of a 900 watt T-20 bulb lamp, which operates at 30 amperes and approximately 28-32 volts, so that we must reduce the line voltage to this value. A specially constructed hand controlled regulator is made for this purpose, which operates at (manufacturers' claim) about 90 per cent. efficiency, hence the 900 watts consumed in the lamp represents 90 per cent. of the total power taken from the lines, that is, 1,000 watts.

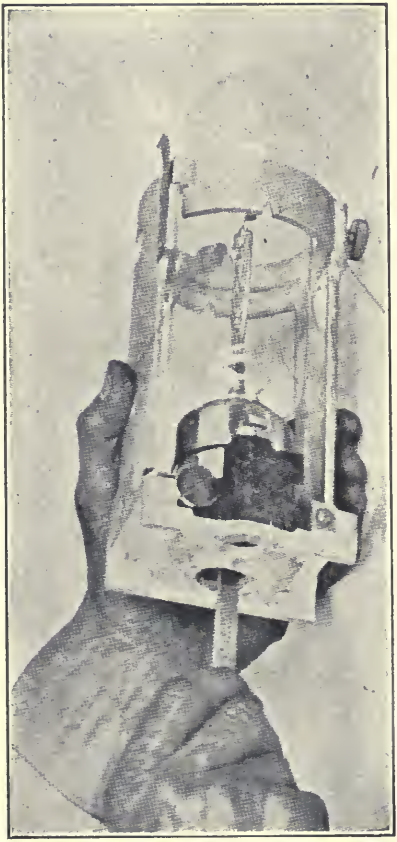


Figure 344.

The difference in wattage consumption would therefore be 1,750 watts in favor of the Mazda lamp.

We must, however, consider another item of cost, viz.: that of lamp renewal and carbon consumption. It is impossible to give accurate figures in these items, but it is safe to assume that the cost of necessary lamp renewals and of carbon consumption will be about equal. The saving through the use of Mazda equipment is, therefore, a matter of a difference in current consumption. Supposing the theatre to be open ten hours a day, the cost of current for operating the carbon arc per year, assuming power to cost .07 cents per kw., equals $.07 \times 10$ (hours per day) $\times$ 365 (days per year) $\times \dfrac{2{,}750 \text{ watts consumed}}{1{,}000} = \$703$. The cost of the Mazda on the other hand is $.07 \times 10$ (hours per day) $\times$ 365 (days per year) $\times \dfrac{1{,}000 \text{ watts}}{1{,}000} = \$256$, so that the actual saving would be the difference between \$703 and \$256, which is \$447 a year.

The relative cost of any Mazda lamp and arc installation operation may be calculated in the same way, merely by substituting the correct values, except that when the power lines supply direct current and A. C. is not available, it is then best to use a small synchronous converter (Fig. 338), which takes D. C. from the lines and delivers A. C. to the lamp. The cost of operation of this form of installation is somewhat higher than straight A. C., because of the higher cost of the converter, but it is much cheaper than taking D. C. through resistance.

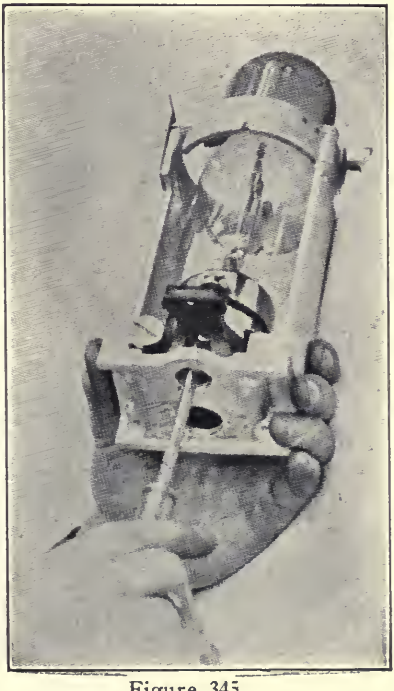


Figure 345.

It therefore resolves itself into a problem, in so far as finances go, as to whether the screen results will be such that the drawing power of the theatre will not be materially decreased, because it would require but a slight loss in drawing power at the box office to amount to the sum saved in current.

There are, however, several other advantages in Mazda lamp equipment. For instance, with Mazda lamps there is nothing like as much heat dissipated in the projection room, therefore the work of the projectionist is made very much more comfortable. Also with Mazda lamps the light source is absolutely steady, and once it is properly adjusted and set going it requires no attention whatever throughout the run, unless the supply voltage fluctuates heavily. With the carbon arc installation there is a certain amount of carbon dust set free in the air, which besides setting up a more or less unhealthy condition for the projectionist, gets into the

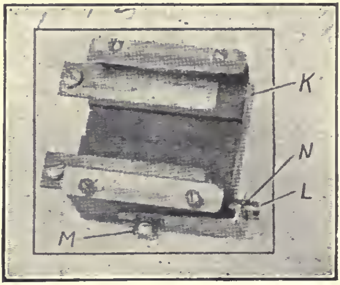


Figure 346.

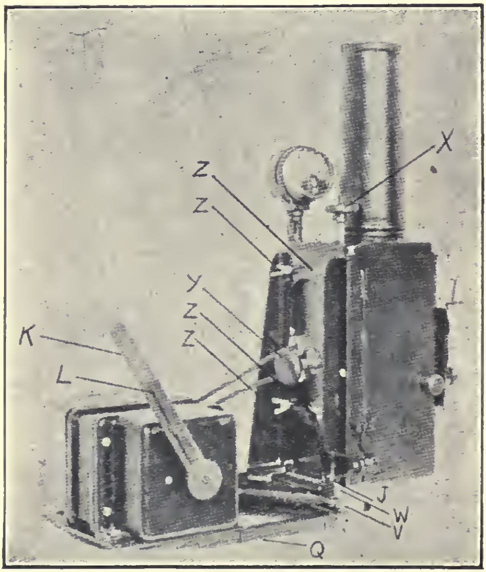


Figure 347.

bearings of a projector and causes considerable wear. Then, too, there is the white ash which is the product of the volatilization of the carbon cores, and there is more or less carbon monoxide gas which is not especially healthful,

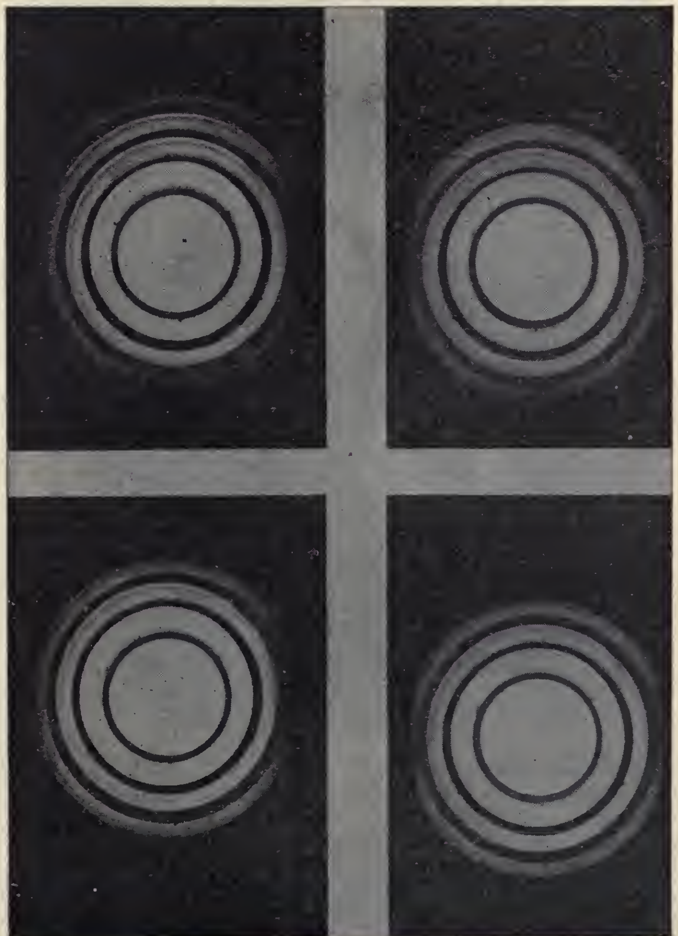


Figure 348.

though as a matter of fact most of it is nowadays carried outside of the projection room. Everything considered, it cannot be denied that the Mazda light source is more healthful and comfortable to work with than is the arc light.

NOT SIMPLE.—Many projectionists have objected to Mazda lamp projection because they believed it would not

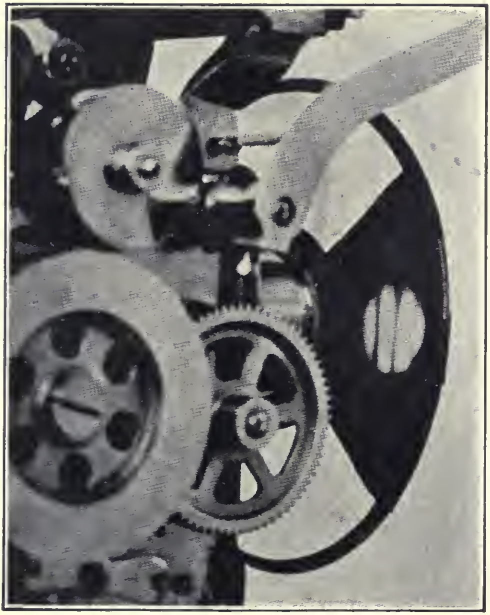


Figure 349.

require much skill to handle, therefore it could be handled by a man of little experience or knowledge. This is a mistaken idea. While it is true that once adjusted the Mazda lamp is rather simple and easy to manipulate, still its adjustment is a very much finer operation than is the adjustment of the carbon arc. It takes real brains and intelligence to get the best possible results out of a Mazda Motion Picture Projector Lamp since it is essential that every possible bit of illumination be got through to the screen.

Another distinct advantage is that with Mazda lamp projection the projectionist really has nothing to do but watch his screen and attend to the projection of the picture, which, after all, is the important thing.

The advantages claimed for Mazda lamp projection may be summed up in the following:

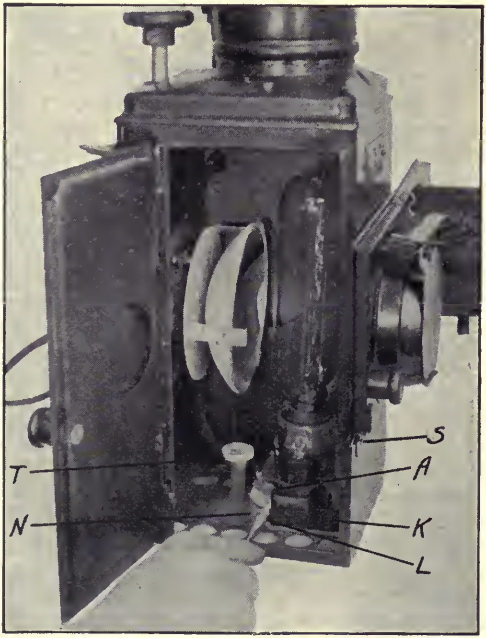


Figure 350.

1. Economy of operation.	Reduction of current bills from 30 to 60 per cent.
2. Steady light.	No variation in light intensity.
3. Soft, pleasing light.	No harsh blue light.
4. Easy of operation.	Lamp once set needs no further attention until removal.

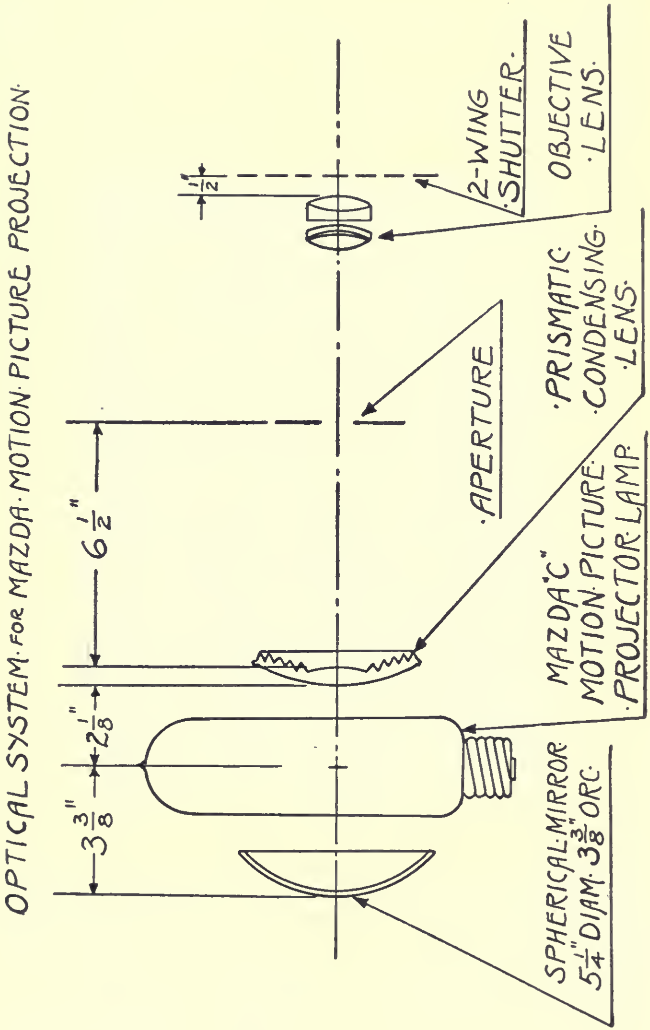

OPTICAL SYSTEM FOR MAZDA MOTION PICTURE PROJECTION
3 3/8"
2 1/8"
6 1/2"
1/2"
2-WING SHUTTER
OBJECTIVE LENS
APERTURE
PRISMATIC CONDENSING LENS
MAZDA "C" MOTION PICTURE PROJECTOR LAMP
SPHERICAL MIRROR 5 1/4" DIAM. 3 3/8" ORC

Figure 351.

5. Prevents excessive heat in projection room.	Wattage dissipated in heat much lower than that of arc.
6. Healthful operating conditions.	No carbon dust or fumes for projectionist to inhale.
7. Longer life of projector parts.	No carbon dust to wear bearings.

Fig. 351 is a graphic illustration of the Mazda lamp line up, the distances therein are all a fixed quantity when using prismatic condensers.

The following is a tabulation of the possible causes and remedies of unsatisfactory screen illumination:

Trouble.	Remedy.
1. Lamps operated under amperage.	Operate at rated amperage.
2. Optical system out of alignment.	See Method of Proper Alignment of Optical System.
3. Lamp burned beyond its useful life.	New lamp.
4. Dirty mirror and lenses.	Clean mirror and condenser thoroughly every day. See "Cleaning Lenses," Page 137.
5. Number one or quarter size projection lenses, 1¾ inch diameter.	Use number two or half size lenses 2½ inch diameter whenever possible, i. e., where focal length is 5 inches or greater.
6. Incorrect distances between parts of optical system.	See method for proper alignment of optical system.
7. Three-wing shutter.	Use a two-wing shutter.
8. Wrong type of screen.	Use screen suitable to the requirements of theatre.

The following is a tabulation of the probable causes and remedies of low average life of lamps:

1. Ammeter out of adjustment.	Correct by checking with standard ammeter.
2. Improper method of lighting lamps.	Always use handle on regulator to avoid initial surge of current.

The following is a tabulation of the probable causes and remedies of uneven screen illumination;

1. Incorrect setting of mirror.	Correct setting. See method for proper alignment of optical system.
2. Lamp filament badly warped out of parallel, or a small section short circuited.	New lamp.
3. Condenser lens out of alignment.	See method for proper alignment of optical system.

THE PLANO-CONVEX CONDENSING SYSTEM.—The Precision Machine Company, makers of the Simplex professional projector, manufacture a Mazda equipment which employs a plano-convex condenser, exactly the same as the plano-convex condenser used in arc light projection. A general view of the Simplex Mazda outfit, with lamphouse doors removed and the condenser casing open, is had in Fig. 352, in which Q is the swinging projector table, exactly the same as is used to support the Simplex Type S lamphouse, or other Simplex arc lamphouses.

To replace the arc lamphouse with a Mazda lamphouse it is only necessary to remove the former and set the latter in

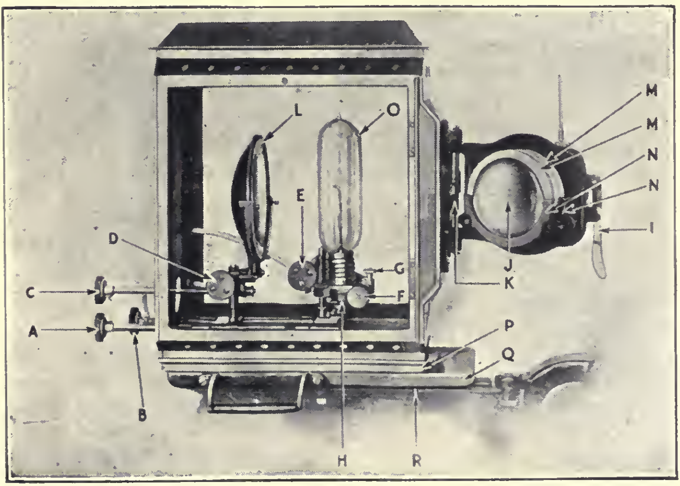


Figure 352.

its place, being sure the base of the Mazda fits down into the grooves properly. When the Mazda lamphouse is in place, be sure and tighten wing-nuts (two of them) R, Fig. 352, which locks it to the swinging table.

The CONDENSER.—The Mazda plano-convex condenser, as used by the Simplex, consists of a 6½ inch focal length collector lens (lens next the lamp) and a 7½ inch focal length converging lens (lens next aperture), both of standard 4½ inch diameter. These lenses are so placed that they are only 1/16 of an inch apart, as shown in Fig. 362. The focal lengths named are never changed. A 6½-7½ combination is the standard Simplex Mazda condenser.

CAUTION.—Be sure there is not to exceed 1/16 of an inch between the apexes of the curved surfaces of the lenses, as shown in Fig. 362, because spacing the lenses further apart alters the E. F. of the condenser combination and throws everything out.

The lenses are held in metal rings, exactly the same as

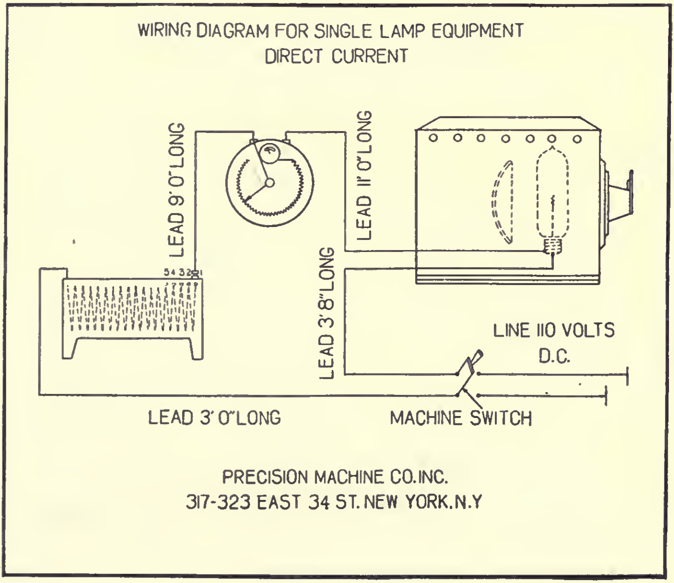


Figure 353.

those used for Simplex arc light condenser lenses. They are fully described on Page 663.

CAUTION.—Do not screw the retaining ring down tight. If you do you will clamp the lens and there will be no room for expansion, which may result in breakage. A good rule is to screw the retaining ring down tight and then back it off about half a turn.

ADVANTAGES.—The advantages claimed by the manufacturer for the plano convex method of condensing Mazda light are (A) greater distance from condenser to aperture. (B) Less divergence of light beam between aperture and condensing lens because of greater distance condenser to aperture. (C) The same condenser may be used for both motion picture and stereopticon projection where a combination projector is used. (D) All adjusting handles are on the outside of the lamphouse. (E) The method by means of which a new lamp is inserted when an old one burns out,

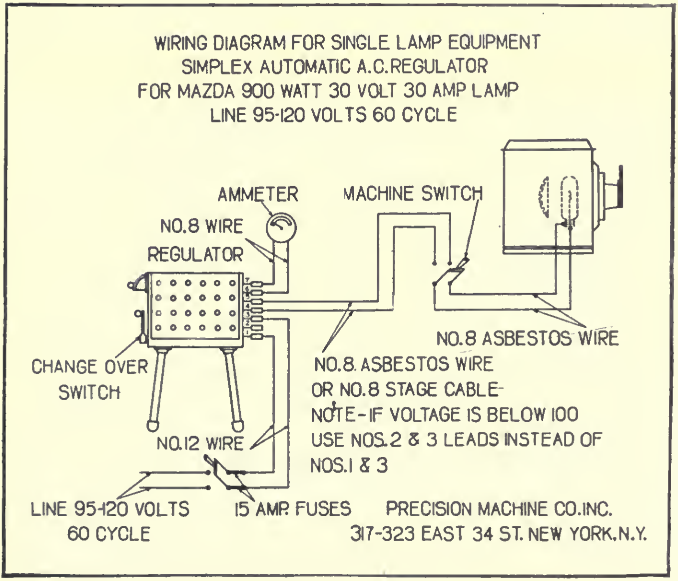


Figure 354.

and the manner in which lining the filament with relation to the lens system.

CURRENT CONTROL.—In order that continuity in action may be had we shall place a description of the current control here, because before attempting some of the operations described further along it is necessary that current be available at the lamp.

Where the current supply is D. C. the Simplex Mazda lamp takes current through an adjustable rheostat, which has such fine adjustments that very slight changes in current (amperage) may be made by the projectionist. This apparatus is illustrated in Fig. 353, in which the method of wiring is shown, A being the amperage regulator. Do your wiring according to the diagram in Fig. 353 and you will be correct.

If the current supply be A. C., then a Westinghouse transformer, called an "automatic regulator," is used. This apparatus is so arranged that it acts automatically to keep the current flow at the rated capacity of the lamp, regardless of

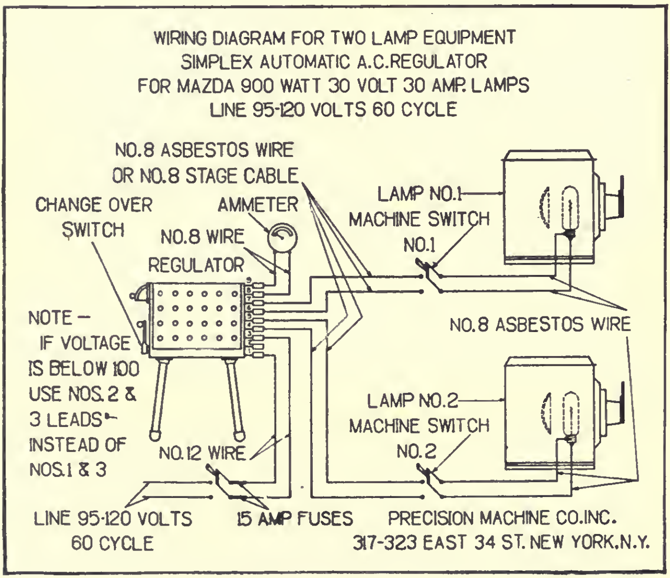


Figure 355.

fluctuations in voltage. The device is unique, in that it may be set to deliver any desired amperage within the range of its capacity, and once so set and locked for a given current flow (merely the matter of moving a handle on the end of the device up or down until the desired amperage flow is accomplished, and the giving of the aforesaid handle a twist to lock it) it will maintain that amperage until the adjustment is changed.

It is also unique in that by the closing of a contact device it will deliver sufficient additional current to heat the fila-

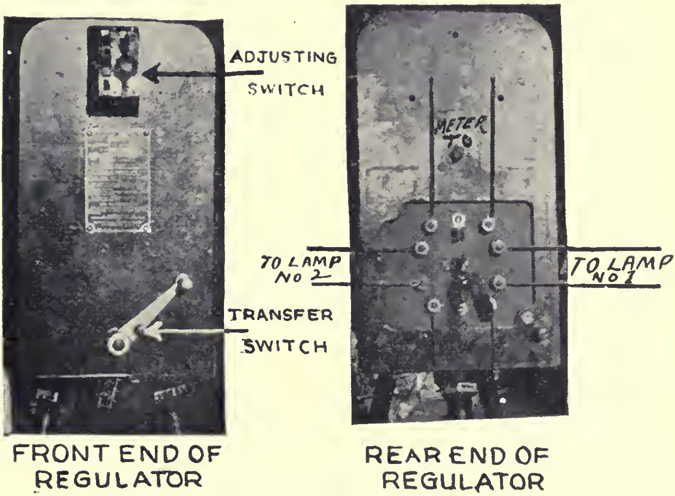


Figure 356.

ment of the idle lamp of a two-lamp installation, without affecting the operation of the lamp on the working projector.

The regulator is a step-down transformer, the primary coil of which moves and automatically changes its distance from the secondary coil when there is change in supply voltage, or other cause tending to alter the current flow at the lamp.

CONNECTING REGULATOR.—The connections for a single and two-lamp installations are shown in Figs. 354 and 355. Connect the line wires, through a D. P. S. T. knife switch, of sufficient capacity, and 20 ampere fuses if the current be 110 volts (if 220 volts, then use 10 ampere fuses) to the terminals marked "LINE" at bottom of regular panel.

CAUTION.—Regulators must not be used on any voltage or current frequency except as per markings on name plate of each regulator.

Connect terminals on regulator panel marked "METER"

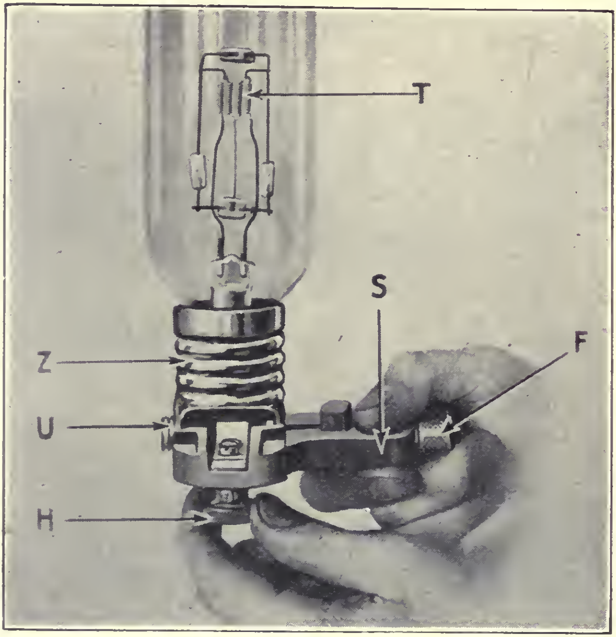


Figure 357.

to terminals of ammeter. If no ammeter is used (which should never be the case), then connect the terminals marked "METER" to each other, using either a good connector (see Fig. 26, page 122) or else solder the joint.

CAUTION.—For good and sufficient reason it is necessary that the ammeter be located at least two feet away from the regulator. We strongly advise that it is located where it

will be in constant view of the projectionist when in position beside the projector. We recommend, and strongly too, that two ammeters be used, one located beside or immediately over each observation port. The extra ammeter will soon pay for itself in the saving effected in lamp filaments through consequent close regulation of the current induced by having an ammeter at all times directly under the observation of the projectionist.

Connect panel terminals marked "LAMP NO. 1" and "LAMP NO. 2" to the respective projector lamps through the projector table switches (the left-hand projector being,

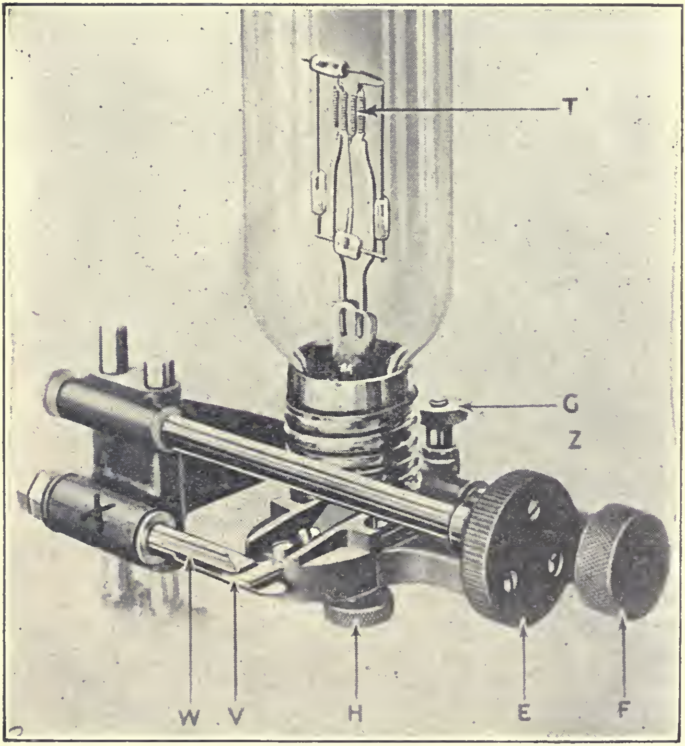


Figure 358.

usually, merely as a convenience in designation, called projector No. 1), which finishes the job.

OPERATION OF REGULATOR.—By examining Fig. 356 you may see the location of all the various terminals and switches, but we will tell you the location anyhow. The transfer switch, located on front of regulator, cuts in either lamp on a low current circuit for the purpose of warming up its filament preparatory to switching the lamp to full amperage. This is for two purposes: (A) To eliminate the shock attendant upon turning full current strength into a cold lamp filament. (B) To enable the projectionist to light the lamp of the idle projector while the other lamp is operating, in order to make any adjustments of the apparatus which may seem necessary.

When the transfer switch is thrown to the right—right when looking at the panel board—lamp No. 1 is connected to the main secondary coil, and is at full amperage, while lamp No. 2 is connected to what is then the auxiliary secondary winding, at low amperage, for warming up.

The line voltage switch, handle of which projects through the terminal board cover, enables the regulator to operate under a considerable range of supply line voltage.

IMPORTANT.—The line voltage switch must always be kept in such position as will prevent the moving coil from remaining in contact with the stop at either end of its travel. As a measure of safety, for lamp protection, the Simplex people recommend that it be kept at "LOW," except when conditions indicate that the position should be changed. ALWAYS HAVE THIS SWITCH AT I)W WHEN STARTING THE LAMP.

TO START LAMP IN OPERATION.—Let us assume we propose using projector No. 1—the left-hand projector. First of all throw transfer switch to the left, and line voltage switch to the position marked "LOW." If it is the first time we have used the apparatus, set the adjusting handle to position marked "30" on scale, which means 30 amperes. Close line switch. Close table switch of projector No. 1, and as soon as lamp filament has come to a glow for about one second (longer will do no harm, but one second is quite sufficient for the purpose) throw transfer switch to the right and immediately examine position of moving coil, though this latter is only necessary occasionally, once the apparatus is adjusted, or after installing a new lamp.

If it is found the moving coil is against, or is too close to one of the stops, immediately adjust the line voltage switch, as before directed.

IMPORTANT.—A few seconds before it is time to change over from one projector to the other, close table switch of idle projector in order to heat up the filament of idle lamp preparatory to switching it to full current capacity. The change from one lamp to the other, aside from the low amperage heating-up current, is accomplished by throwing transfer switch to opposite position.

CAUTION.—After installing a new lamp, always examine the ammeter, and by means of the adjusting switch, so regulate the current flow that it is just 30 amperes.

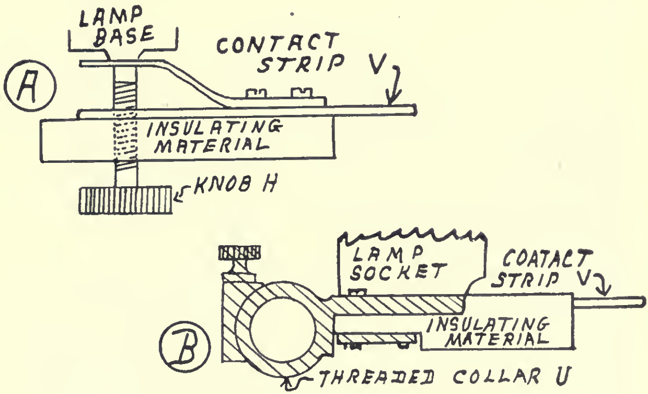


Figure 359.

IT IS ESSENTIAL THAT AN AMMETER BE USED. The adjusting switch scale may be depended upon for a fair degree of accuracy, but that is not sufficient. If you want maximum service from your lamps you must have EXACT accuracy, and that may only be secured by the use of a good ammeter.

TAKE NOTICE.—We strongly recommend that users of Mazda projector lamps have their ammeters tested at least once a year. It will pay you to do it. An ammeter registering low will cause constant overloading of your lamp filaments, and thus very greatly shorten the life of the lamps.

We would also caution you against deliberate overloading of lamp filaments. The projectionist may get much more light all the time by boosting the amperage above the rated capacity of the lamp, or he may boost it when a dense scene comes through, but if he does so he has no right to complain if the lamp filaments warp, sag or burn out very quickly, or at least last very much less than their estimated span of life.

Never use such an outfit as is shown in Fig. 353, except for D. C. If your current is A. C. use the regulator. The rheostat may be used on A. C., yes, but by comparison with the regulator it is extremely wasteful.

THE LAMP HOLDER.—The lamp used is a 900 watt, 30 ampere, 30 volt Tungsten filament lamp. The coils of such a lamp are shown, full size Fig. 317. The lamp is held in a socket Z, Fig. 357, very similiar to the ordinary lamp socket, except that the lower central-contact of the socket is movable, or adjustable as to its height.

Examining Figs. 357 and 358 you will note knurled-head thumb screw H. The upper end of this screw presses against a spring blade, which is raised as the thumbscrew H is screwed in, and is lowered as it is screwed out, or down. The center contact of the lamp makes contact with this spring blade which carries current to the lamp from one side of the line. The need for this adjustment is as follows: When the lamp is inserted it is screwed into the socket as far as it will go, but in this position it is probable the filament will not face the lens squarely. It will therefore be necessary to unscrew it a part of a turn, which has the effect of altering the distance the center contact of the lamp will be from the bottom of the socket when it, the lamp, is in operating position. From this you will understand the need for the center contact of the lamp being adjustable as to height. The detail of this contact is diagramatically illustrated at A, Fig. 359. The lamp holder, as a seperate unit, is shown in Fig. 357.

TO PLACE LAMP IN HOLDER.—First lower knob H, Fig. 357, as far as it will go. Then screw lamp into socket as far as it will go, then see if the face of the filament is parallel with (in line with) knob F. Fig. 360, and the shaft it controls. If not, then unscrew the lamp from the socket enough so that the filament is in line, whereupon tighten the knob H, Figs. 357 and 358 until firm contact is made with base of lamp. The tightening of knob H serves two important purposes, viz.: (A) It forms electrical contact between the lamp base and contact strip, as per Fig. 359. (B) It locks the lamp into the socket, thus making good electrical contact

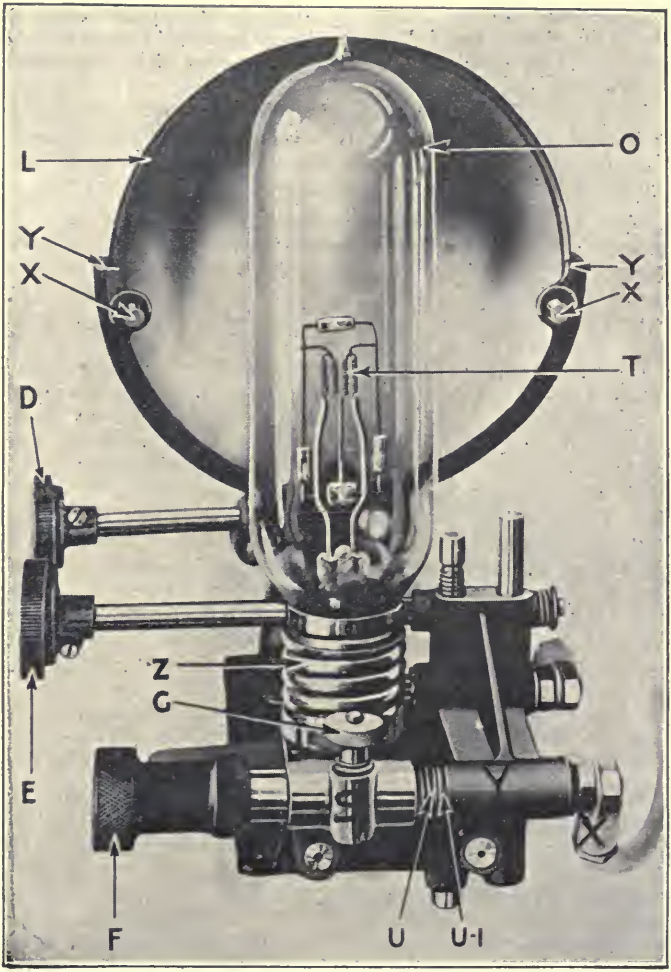


Figure 360.

between the metal of the socket and the metal of the lamp base. **You therefore will understand the importance of setting knob H up firmly.**

PLACING LAMP IN LAMPHOUSE.—Each lamp must first be placed in a holder as per preceding instruction, and the holder afterward installed on the lamp base in the lamphouse. The method of connecting the holder to the base is simple; also its removal from the base is equally simple. To install a holder containing lamp, proceed as follows. In Fig.

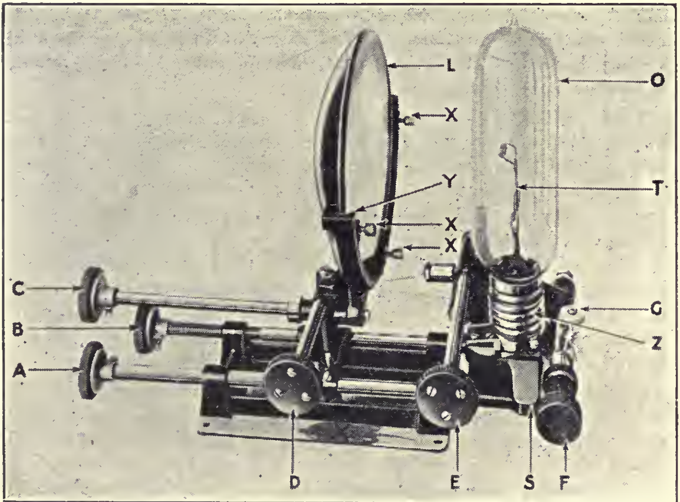


Figure 361.

358 you see contact strip V. At A, Fig. 359 you see what it is and what it connects to. In Fig. 360 you see the side of lamp holder opposite to the side shown in Figs. 358 and 361, and at B, Fig. 359, you see a drawing of the back end of the lamp holder. As shown at B, Fig 359, threaded collar U, Fig. 360, is really a hollow shaft, on the opposite end of which knob F, Fig. 358, is mounted.

To insert the lamp holder, shove it past knob E, Figs. 358 and 361 and engage contact strip V, Fig. 358, with slot in part W, as shown, at the same time entering a stud which protrudes from lug Y, Fig. 360, into the hole in end of threaded collar U, Fig. 360, and shove the holder in as far as it will go.

By way of explanation, a metal stud passes through and is gripped and held by lug Y, Fig. 360. To one end of this stud wire X attaches, as shown. The other end extends beyond the left hand end of lug Y to a considerable distance, and forms the support for one side of the lamp holder. It also forms the current carrying connection between wire X and lamp socket Z, Fig. 360.

CAUTION.—After inserting lamp holder, be sure and tighten thumbscrew G, Fig. 360, which locks parts S and stud into good electrical contact. Unless this be done there may be arcing between the two parts, which may, in time, either injure or ruin them.

THE MIRROR.—In order that the light from the back side of the filament be not wasted, and that the light source present to the lens a solid, unbroken surface, a spherical mirror is employed, placed as per Figs. 360 and 362. The reasons for this mirror, and an explanation of its action will be found in the text matter, page 819.

It is of course vitally important that the mirror be so placed that the image it reflects, or projects, will fall exactly in its appointed place, and the Simplex equipment provides ample adjustments, in convenient form, to enable the projectionist to place the image exactly where he wants it.

CLEANLINESS.—It is essential to efficient results that the mirror be kept perfectly clean. You must polish its surface daily. This may be done by washing it with a solution of half wood alcohol and half water, or with gasoline, polishing the surface while still wet. It may also be done by breathing on surface while mirror is still cold, and polishing with a perfectly clean, soft cloth, or with tissue paper.

We would recommend to theatre managers that they provide, for the purpose of cleaning lenses, a roll of soft high grade toilet paper. Such paper is most excellent for the purpose, and clean lenses mean much in excellence of screen results.

To remove or insert a mirror it is only necessary to loosen thumb screws X-X-X (three of them), and insert or take out the mirror, as the case may be.

CAUTION.—After inserting a mirror, be sure to tighten thumb screws X-X-X, but only sufficiently to hold the mirror in position, without exerting undue pressure. **DON'T jam the**

thumb screws down tight, unless you want a broken mirror.

DISTANCE.—FILAMENT TO MIRROR.—Distance center of back of mirror from lamp filament must be as shown in optical diagram, Fig. 362. This is important to good results The correct distance may be obtained by turning knob A, Fig. 361 in the required direction.

Having placed the mirror in position and secured the correct distance back of mirror to lamp filament, unlock the mirror by turning knob D, Fig. 361, to the left, and swing the mirror to one side as far as it will go by means of knob G, Fig. 361, locking it there by means of knob D. This is to prevent focusing the filament image, which is not desired at this stage of the proceedings.

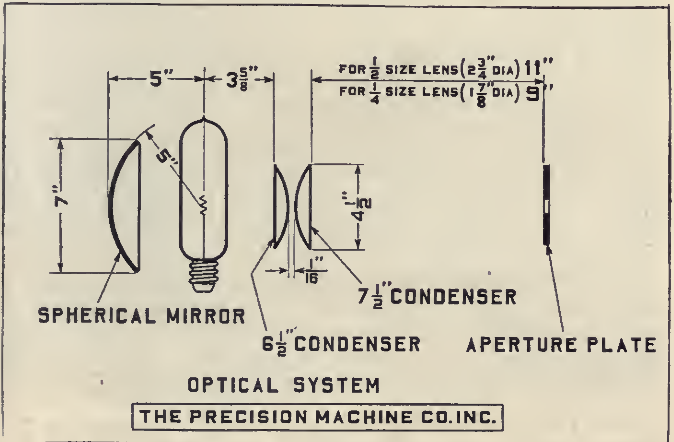


Figure 362.

LOCATING THE LAMP FILAMENT IMAGE.—In the center of the douser is a pin hole. Light your lamp and you will find an image of the lamp filament projected through the pinhole to the automatic fire shutter, upon which it must be centered. Should the image be either too high or too low, it may be raised or lowered by means of knob E, Figs. 352 and 361, which raises or lowers the lamp as a whole. The image may then be centered sidewise by first loosening thumbscrew G, Fig. 360, and turning knob F, which moves the lamp sidewise.

NOTICE.—If it is desired to move the lamp toward you it is only necessary to turn knob F to the right, but if you wish to move the lamp from you you must turn knob F to the left, **and at the same time shove the lamp holder in.** This is because the threads on threaded collar U, Fig. 360, engage with threads in part S, Fig. 360, while collar U merely butts up against the end of lug Y, hence turning knob F to the right will pull the lamp back, turning it to the left will have no effect, unless you shove in on the holder at the same time. Examine the parts and you will see how it works. Be sure and tighten thumbscrew G, Fig. 360, when you are through.

FOCAL DISTANCES.—Examining the optical diagram, Fig. 362, you will see what the focal distances must be. They are the distances recommended by the manufacturer of the apparatus, who certainly should know what is best. You doubtless will be inclined to question the recommendation of nine inches from front surface of condenser to aperture when a small diameter projection lens and eleven inches when a large diameter projection lens is used, since this is exactly opposite to the usual condition recommended, but the figures are correct nevertheless. The apparent contradiction in distances is due to the fact that the longer distance with the larger lens is necessary in order to overcome chromatic aberration.

CAUTION.—DON'T guess at distances. Use a ruler and get them exactly right. You are not working with an arc lamp now, and cannot make surplus light available to offset the waste attendant on "guess work," therefore stop guessing and do your work right if you want satisfactory results.

LOCATING FILAMENT.—The lamp filament must be 3⅝ inches from the face of the collector lens, as per Fig. 362. By means of knob B, Fig. 361, move the lamp backward or forward until, using a ruler, you have the filament exactly that distance from the face of the lens. When you get the filament the right distance, close the lamphouse door and move the filament locater in the lamphouse door backward or forward until you can see the lamp filament through it, whereupon tighten the holding screws of the locator. This device is to enable you to place the filaments of new lamps you install the correct distance from the lens. Once set, as above, when you install a new lamp you have but to move it backward or forward until the filament can be seen through the locator tube, and it is exactly the right distance from the lens. It is very important that this distance be precisely right.

FOCUSING LAMP FILAMENT.—If you have followed the instructions to this point, you have the lamp installed, its filament correctly centered with the aperture and at the right distance from the collector lens. You must now proceed to focus the filament as follows: Remove the projection lens, open the automatic fire shutter and block it up so that the aperture is open (no film in projector of course) and move the revolving shutter out on its shaft until its blade is exactly

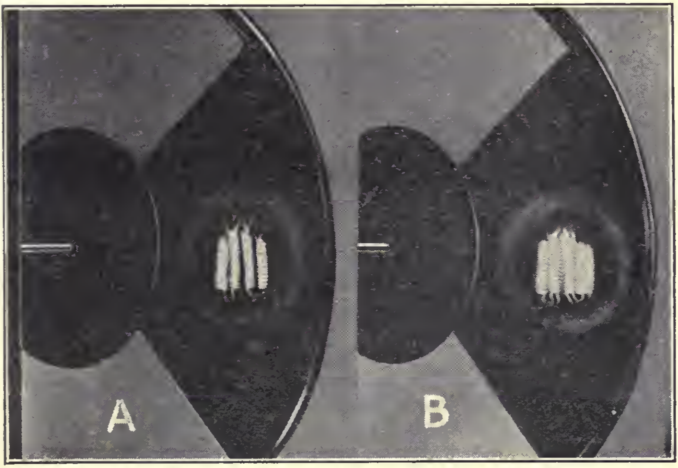


Figure 363.

10¼ inches from the aperture. Instead of moving the shutter you may, if you prefer, support a piece of dark colored cardboard or sheet metal 10¼ inches from the aperture to serve as a screen. Now light the lamp and you will find an image of the lamp filament on the shutter blade or the cardboard screen, as per A, Fig 363. By means of knob B, Fig 361, move the lamp, as a whole, backward or forward on its base until the filament image is as sharp as you can get it.

FOCUSING THE MIRROR IMAGE.—When you have the filament image sharp, unlock the mirror by turning knob D, Fig. 361, to the left, and by means of knob C swing the mirror over until the mirror image of the filaments appears on the shutter blade or cardboard screen. This image will be much less brilliant that the filament image itself.

Next, by turning knob A, Fig. 361, we make the mirror image as sharp as possible and then, using knob C, Fig 361, which swings the mirror sidewise, and knob D, Fig. 361, which causes the image to raise or lower, so locate the mirror image that it exactly fills the space between the filament coils, so that the image appears as at B, Fig 363.

Now replace the projection lens, and lock the mirror in place by means of knob D, Fig 361, and the job is finished.

The entire adjustment should now be complete and correct, and the screen field should be clear. Should there be discoloration, slowly move the entire lamphouse backward or forward until it disappears, after which tighten wing-nuts (two of them) R, Fig 352.

NOTE—It is quite possible to complete the entire placing and focusing of both filament and mirror images on the automatic fire shutter, using the pin hole in the douser, but experts at the Simplex factory tell us the revolving shutter blade or card board screen gives more accurate results.

EXTRA LAMPS.—It is necessary, or at least highly advisable that one or more extra lamps be on hand, adjusted in spare lamp holders and all ready for immediate insertion in the lamphouse. Failure to take this precaution may, and probably will cause an embarrassing situation as the audience waits while you install a lamp in its holder, and the holder in the lamphouse, the first named proceeding probably requiring a longer period of time that the second.

INSTALLING EXTRA LAMP IN LAMPHOUSE.—First, before attempting to remove the old lamp, be sure the projector table switch is "open." Then, having the spare lamp properly installed in its socket, as per instruction already given, loosen thumb screw, C, Fig. 360, and pull old lamp and its holder out, after which insert the holder with new lamp as per instruction: "Placing Lamp in Lamphouse." Next close projector table switch, bring lamp up to normal amperage, center filament image on automatic fire shutter and mirror image between coils. Resume projection, and, if necessary, move lamphouse backward or forward to get as clear a field as possible until opportunity is had to complete a perfect adjustment.

NOTE.—If current be D. C. move regulator to "Low" as soon as projector table switch is pulled. If current is A. C. set regular line voltage switch at "LOW" as soon as table switch is pulled.

COMPARISON OF CRATERS.—The General Electric Company has provided us with the data needed for intelligent comparison of the ordinary and the high intensity arc. This data is found in the following table, which is self explanatory, insofar as undertanding its data goes:

Kind of arc	Amperage	Carbon diameter	Crater diameter	Crater Depth	Lumins in Beam	Avg. Ft. Candles on Screen
Low Intensity	50	3/4 Pos. 5/16 Neg.	.47"	.12"	688	5.83
Low Intensity	75	7/8 Pos. 13/32 Neg.	.56"	.17"	1035	8.77
Low Intensity	100	1" Pos. 9/16 Neg.	.66"	.55"	1480	12.55
High Intensity	50	9 mm Pos. 9 mm Neg.	.27"	.05"	1437	12.2
High Intensity	75	11 mm Pos. 11 mm Neg.	.35"	.11"	2700	22.9
High Intensity	120	13.7 Pos. 11 mm Neg.	.48"	.34"	4950	41.9

Condensers used for tests 6½ and 7½ plano convex.
Projection lens 5" E.F., 1 7/16 Dia. Speed F 3.4.
Screen 9' 7" x 12' 4".

NOTE.—1 mm equals .03937 of an inch.

This data was received after the rest of the high intensity data was compiled. It is interesting to observe the great difference in carbon size and crater diameter. For equal amperage it will be observed that the crater diameter is but little more than one-half for the high intensity. This should enable the projectionist to retard his condenser, use a short focal length condenser and reduce the beam divergence beyond the aperture to a value which will enable the projection lens to pick up the entire beam from a 120 ampere arc, a thing which will be highly beneficial in more than one way.

ARMS AND LEGS ARE CHEAP — USE YOUR BRAINS.

Weaver Douser

AN ELECTRIC DOUSER.—The change-over is facilitated by what is known as the Weaver Electric Douser, which works by magnetic action and cuts off the light from one projector, substituting that of the other simultaneously, or at least in the very small fraction of a second. The action is in fact so rapid that it is practically instantaneous.

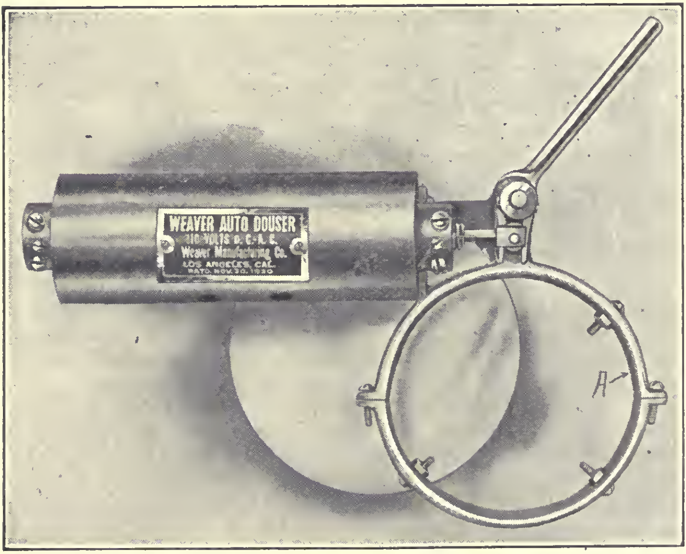


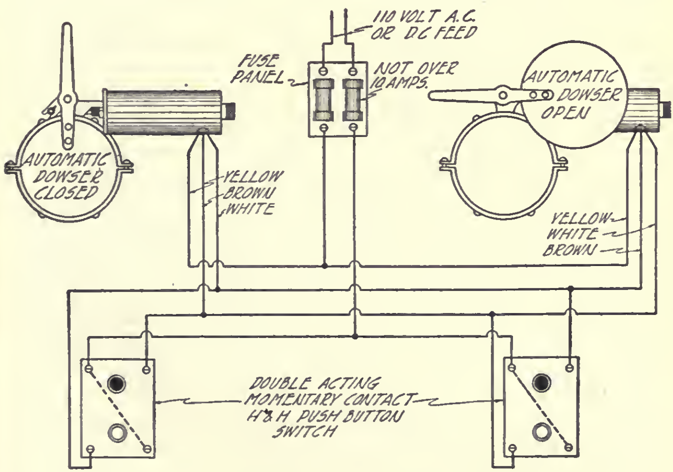
Figure 363-A.

In Fig. 363-A we have the photographic view of the douser, and in Figs. 363-B and 363-C wiring diagrams for two and three-projector installations. It is also quite possible to add other switches, so that the douser may be set into action from any desired point in the projection room, though this latter we do not either value or recommend, because we hold that the projectionist should be beside the projector, where he rightly belongs when a picture is being projected.

The douser is clamped to the front of the condenser cone by means of ring A, Fig. 363-A. The method of attachment is made quite evident from an examination of the picture. One push button switch is located on or near to each projector. It is possible to locate other push buttons at the re-winder table or elsewhere, if desired. These switches must, however, be of such type as will make contact ONLY when the button is pressed down. If the current be D C, then it is advisable to use an "H and H" switch. In any event if the current be D C a switch which will not arc must be selected. If the current be alternating, then any type of momentary contact may be used.

CAUTION.—Switch should always be kept lubricated to prevent possibility of sticking. The douser circuit must be fused, and the fuses must not exceed ten (10) amperes capacity.

Wires attached to douser are colored. Yellow wire connects douser to line, through a S. P. S. T. knife switch. Light



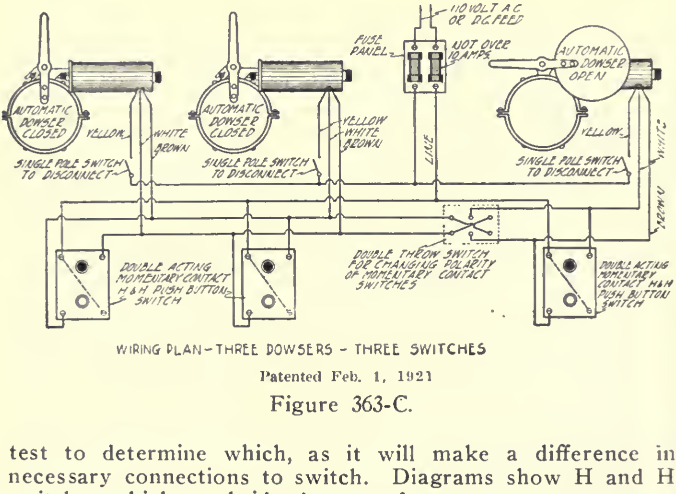
WIRING PLAN—TWO DOWSERS—TWO SWITCHES

Figure 363-B.

brown wire closes douser. It is attached to white wire of other douser, and through it to one terminal of each switch, as shown.

White wire connects to brown wire of other dousers, and through it to one pole of each switch. The third pole of the switches connects to the line. It is all made very plain in Figs. 363-B and 363-C.

CAUTION.—Before connecting white and light brown wires to switches, test the circuits and see that they are open except when switches are operated. All momentary contact switches have two "hot" legs. They are sometimes bridged across one end and sometimes from corner to corner. Always



WIRING PLAN—THREE DOWSERS - THREE SWITCHES

Patented Feb. 1, 1921

Figure 363-C.

test to determine which, as it will make a difference in necessary connections to switch. Diagrams show H and H switches which are bridged across from corner to corner.

Should dousers open or close too far, or not far enough, loosen lock nuts at end of coil box and screw the brass bumpers in or out, as need may be until the correct adjustment is had.

Should douser fail to remain open while projector is in operation, remove taper pin in slot, stretch spring to give it more tension, and replace.

TO OPERATE.—The douser may be operated by hand whenever desired. The hand operation of one douser will in no way affect the other. To operate electrically, push button of switch and release IMMEDIATELY.

Automatic Curtain Machine

UNDER many conditions there can be no question but that a curtain before the screen adds largely to the "tone" of the performance. This is especially true in theatres where the screen is on a stage, or is located in a cove-like structure.

VALLEN AUTOMATIC CURTAIN MACHINE.—There is now on the market a device known as the Vallen Automatic Curtain Machine, illustrated in Fig. 364. This machine is very simple. It consists of a motor connected to a cable drum by suitable gearing. The machine once started is automatic in its action, and its controlling switch may be located either

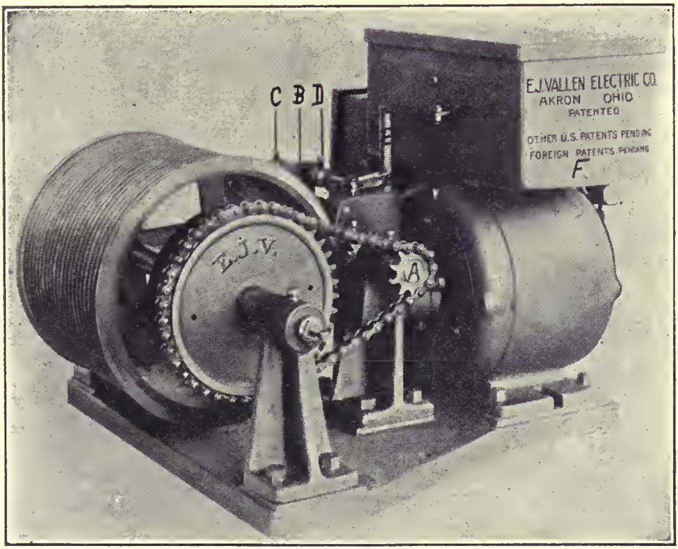


Figure 364.

in the projection room, or elsewhere, or may be controlled from two different points.

This forms an ideal installation, because with the switch conveniently located in the projection room, where it may be reached from working position beside either projector, the projectionist can close the curtain machine switch and start his projector at the same time, whereupon the title of the picture is projected on the curtain, and is gradually revealed on the screen as the curtains are pulled away, or as the curtain is raised by the machine, as the case may be.

In Fig. 365 we have a diagrammatic representation of the device, its location, and the cable arrangement and connections with the curtain. The machine may either raise and lower the curtain, pull curtains sidewise, as per diagram, or it may loop them up and back them away from the screen. The practice in many of our best theatres is to suspend cloth curtains down over the screen from above, and to disclose the screen by draping or looping them back sidewise.

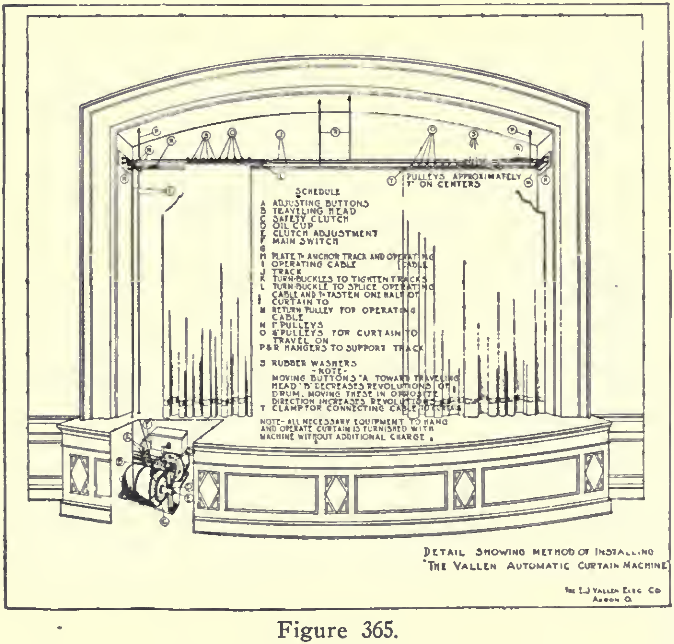


Figure 365.

When the curtains are to be pulled sideways they are suspended from and attached to cables I-I, Fig. 365, which, it will be seen by examining the arrangement, travel horizontally and in opposite directions above the screen, so that when the drum is running in one direction the left hand curtain will be pulled to the left, and the right hand curtain to the right, the direction of the curtains being reversed with the reversal of direction of motion of the drum.

The practice pursued in many of the best theatres is to loop the curtains back. This is accomplished by using only one cable and branching it, attaching one branch to the front edge of each curtain, down far enough so that when the cable is pulled back the curtains will clear the screen. In this plan the opper end of the curtains is not attached to the cable, but to the walls or to some rigid support, so that the curtains are not separated at the top.

The motor of the Vallen machine is specially designed, over size motor, built by the Robbins and Myers Company. Its starting, stopping and reversing is accomplished by means of an automatic switch and a mechanism designed specially for the purpose. Where the control is from the projection room, which is the plan we would strongly recommend, a four pole, double-throw, manually operated switch is located therein, **in a position to be reached from working position beside either projector.** Closing this switch in one position will start the curtain machine, after which it requires no further attention, as it will continue to operate until the curtains have reached the limit of their travel, whereupon the machine will automatically stop. When ready for the next operation it is only necessary to close the switch in the opposite direction. **To open the curtains the switch is closed in one direction, and to close them the switch is closed in the other direction.** That is all there is to it.

The opposite end of shaft A, Fig. 364, is threaded, and upon it rides travelling head B, which same constitutes the controlling element of the machine. Collars C-D are adjustable on rod G, which, in turn, operates part E, which in its turn operates an automatic switch located inside box F. It will thus be seen that when travelling head B comes in contact with collar C or D, it will move rod G, and thus, through the movement of part E, open the automatic switch and stop the machine. The time the motor will run will depend upon the position of collars C and D, therefore, within the limits of the machine, merely by changing the adjustment of collars C and D, it may be made to pull the curtain or curtains any desired distance.

Besides the automatic controlling switch F, is an externally operated fused switch, designed to protect the motor. This switch does not show in Fig. 364, but is indicated at F in the diagram, Fig. 365. The threaded shaft by which the travelling head is controlled is so constructed that in case either one of collars C or D should become loose, the motor will continue to operate until travelling head B reaches the end of the threads, whereupon it will stand idle. This prevents possibility of damage to the machine. Also by means of a mechanical safety clutch, described further along, no damage will be done to the curtain.

On the inside of box F there is a safety arm, which is securely connected with travelling head B, so that in case the automatic switch for any reason does not work at the proper time, an instant later the safety arm throws the switch to open position, and stops the motor, which same cannot be again started until the cause of the trouble is removed.

We therefore see that the machine is pretty well foolproof, as well as very thoroughly automatic, and while we have not actually examined the device, the photograph indicates a rugged and excellent form of construction.

The bearings of the motor are of bronze. Some of them have an oil well and are lubricated by means of oil rings, as per Fig. 148, page 448, while others are lubricated by means of a wick system. These latter have an oil cup on top of the bearing. The chain is a roller chain, the same as those used on motorcycles. The grooves on the drum are worm grooves, which insures the cable winding properly.

MECHANICAL CLUTCH.—The drum is fastened to the shaft, which sprocket H is not, but idles thereon. On the inside of sprocket H is a mechanical clutch, with an adjustment screw, I, Fig. 364, extending from the end of the shaft on which the sprocket runs. By means of adjustment I, sprocket H can be made to move the drum when it is pulling any desired load. The object of the clutch is protection, both to the curtain and to the electrical part of the machine. In case the cables should get caught, or in case collars C and D worked loose and travelling head B was thus allowed to go too far, instead of tearing the curtain or stalling the motor, mechanical clutch H will slip, thus allowing the motor to run without operating the drum.

The base and all the bearings supports are of cast iron, but the drum is aluminum. Travelling head B is of semi-steel, and the switching mechanism of bronze. All parts of the machine are interchangeable, and every machine is guaranteed indefinitely against structural defect, so that any fault due to defective material or workmanship will be replaced without charge.

OPERATING DIRECTIONS.—Each bearing support for the drum has one oil cup, the bearing for the gear two oil cups, and each motor bearing one oil cup. A few drops of the same oil you use on you projector (if you use good oil) in each of the bearings once a month, and a few drops on the threaded shaft and the roller chain once a month is sufficient.

To locate trouble in case the motor will not run, it is necessary to:

(A) See that the main line switch is closed.

(B) Test the fuses.

(C) Inspect for loose electrical connections in box F, Fig. 364.

(D) See that the projection room controlling switch is making proper contact.

(E) Open box F, Fig. 364, and see if the safety arm has thrown the switch to "open" position. If so, the spring has either become disconnected or is broken.

Collars C and D, Fig. 364 are adjustable. Moving them away from the travelling head causes the curtain to travel a greater distance, and moving them toward the travelling head causes the curtain to travel a shorter distance. For instance, if the curtain is not completely closed, start the machine and allow it to operate in the direction of closing the curtain. If it stops automatically when the curtain is not quite closed, the button which is then nearest the travelling head should be moved away from the travelling head, not more than one-sixteenth of an inch. Having made this adjustment, let the machine again open the curtains and close them. If it does not quite close this time, move the collar a trifle more. To cause the curtains to open farther, the same operation is necessary at the other end of the travelling head. When the curtains are open the button nearest the travelling head must be moved a bit further away, if it is desired to have the curtain open wider, or it must be moved toward the head if the curtains opens too much. **One eighth of an inch movement of collars C-D represents an eight inch change in the travel of the curtain.**

SLIPPING CLUTCH.—To locate the cause of the clutch slipping:

(A) Main line switch should be opened.

(B) All cables, pulleys and the curtain should be examined, to make sure nothing has become fouled. After locating the trouble and repairing same, close the main line switch and start the machine to make sure everything is all right.

Should the mechanical clutch slip under the load the machine is pulling, turn adjusting screw I to the right one-quarter of a turn at a time until the slipping stops.

CAUTION.—The adjustment of the mechanical clutch is important. Screw I must be so adjusted that the clutch will just pull the normal load the machine is called upon to handle. The clutch is a safety device and must not be tight enough to pull anything more than its normal load. If the curtain does not open and close completely, do not adjust the clutch differently, but locate the cause that has made it slip.

Projectionist's Report

IMPORTANT.—Every exhibitor should require his projectionist to make written report, on a proper blank form, of the condition of all films received from the exchange, or from another theatre, if the service is on circuit.

Such report would entail some work, but the projectionist should, for his own protection, be willing to make it up. It should include a statement of the general condition of each subject and the number of mechanical faults found therein.

The report should be made in duplicate, one copy retained in the theatre files and the other forwarded to the exchange MANAGER.

These two things constitute the value of the report, because with such reports available in the theatre files, the exhibitor is able and ought to make complimentary comment on the condition of the film if the condition deserves it, when paying the film rental bill. On the other hand, if the condition of films is deserving of criticism it is the duty of the exhibitor to make emphatic comment on that fact, and to send an emphatic protest when he sends his check for service.

If this procedure is followed by enough theatres, there can be no question as to its beneficial effect. The exhibitor should remember that the better the condition of the film, the better show will be placed on the screen. It is perhaps unnecessary to further remark that the better the show, the greater will be the patronage of his theatre.

AN OUTRAGE.—The exhibitor should also remember that when he buys service (except in cases where the service is "on circuit") he is paying for films in perfect mechanical condition, other than such defects as may naturally be expected if the films have been used for a considerable time. These latter defects include rain, the possibility of worn or strained sprocket holes and missing sections of film.

They most emphatically do not, however, include misframes, loose splices, torn film or broken sprocket holes.

The exchange which sends out films in any other than perfect physical condition, is so far as concerns splices, absence of misframes, torn film and torn sprocket holes, **is not keeping its contract with the exhibitor.**

The exchange which does these things is working an outrage on both the exhibitor and the projectionist. It is not living up to the true meaning of its contract with the exhibitor and is forcing or attempting to force the projectionist to perform its inspection and repair duties without pay.

The author of this work is most emphatically of the opinion that it is a legitimate and important function of projectionists' unions to take up the matter of films received by their members in other than perfect physical condition, in so far as applies to splices, torn sprocket holes, torn film and misframes, and to take such steps as may be necessary to force reform.

To attempt to project films containing loose splices, torn sprocket holes or torn films is dangerous. To project films containing misframes discredits the work of the individual projectionist, and through him discredits the organization to which he belongs. **It is no part or parcel of his duty as projectionist to make repairs which are presumed to be made by the exchange, and which the exhibitor is paying to have made by the exchange.**

We would suggest the following as in the nature of a good report though it may be changed to suit the individual idea, provided the points named be covered:

PROJECTIONIST'S REPORT

Date ....

Film received from..

Name of Subject ....

No. and kind of faults found therein ....

....

....

....

....

Were films rewound before being shipped away?............

Inherent faults in the film, if any..........................

....

....

Remarks ....

....

....

........................., Projectionist.

Warning

THOSE contemplating the erection of theatres or the remodeling of an old one, should not leave the matter of the location or planning of the projection room entirely to the architect. There should be a stipulation in the agreement requiring the architect to consult with and be guided by the advice of a competent projection engineer in so far as concerns the projection room location and its planning. It would also be well if a competent projection engineer be called into consultation with regard to the screen, its immediate surroundings and the lighting of the orchestra pit.

No matter how thoroughly competent an architect may be as to the planning of theatres, it by no means follows that he has competent knowledge of the requirements of either theoretical or practical projection.

As a matter of fact some of the very best architects in the country, including those who have planned some of the finest Broadway motion picture theatres, have perpetrated the most atrocious, outrageous blunders imaginable in projection room location and planning, and these blunders have operated to forever injure and deteriorate the screen results in those theatres, and thus decreased their drawing power.

Except in isolated cases it also is poor practice to allow the projectionist a free hand in projection room location and construction; also, except in the case of men with wide experience, the projectionist should not be allowed a free hand in the selecting of projection room equipment, because but relatively few projectionists have complete knowledge of the various problems involved in the location and the planning of the projection room, and except in the case of projectionists of wide experience, who have made a real study of their profession the projectionist is likely to be prejudiced in favor of the equipment with which he is most familiar, and unable to make a really intelligent comparison of the merits and demerits of the various types of equipment on the market.

It must be remembered that, while the projectionist may be a very competent man in so far as his knowledge of theoretical and practical projection be concerned, still, unless his experience has been very wide indeed, it is hardly

possible that he can be sufficiently familiar with all the various kinds and types of equipment used in projection work to be able to select the best there is to be had. It also must be remembered that neither the manufacturer or his engineer can be depended upon to say that the goods of a rival manufacturer are best. They have goods to sell and their business is to sell them. They may honestly believe theirs to be the best equipment, but in the very nature of things they are prejudiced and hardly able to make an unbiased comparison.

There are now available a few really competent projection engineers who have no "ax to grind" in the matter of equipment. **These men should be consulted. Not only should they be asked what equipment is best, but the exhibitor should insist that the engineer make clear the reasons why the equipment he names is best.**

In the matter of projection room planning and location, the foremost professional projector manufacturers have available a technical engineer who is entirely capable of giving competent advice. We would suggest that the exhibitor decide upon the kind of projector he is going to install, even before he plans the theatre, and then oblige his architect to consult with and be guided by the technical engineer of the projector manufacturer he proposes buying from in the matter of projection room location and plans.

The author of this book also is willing to act in an advisory capacity with regard to projection room location and plans. In his case, however, there is a charge for the service, and while this charge is quite reasonable, the services of the projector manufacturer's technical engineer may be had free of cost.

Remember that the box office income of the theatre will be injured by anything that injures screen results. It is therefore not good policy to place high-class screen results at the mercy of an architect who, however learned he may be along general construction and decorative lines, knows little or nothing about practical projection, and probably not overmuch about the technics of projection. Such a course cannot but result in the hampering of the work of the projectionist, and the injury, to a greater or less extent, of the results on the screen.

Consulting a competent projection engineer in matters of this kind will save you money in the end, even though it is necessary to pay a fee for his services. The return should be, and in all human probability will be, at least a hundredfold.

Projectionist's License

IN the past there has been considerable opposition on the part of theatre managers and exhibitors to projectionist license laws. Also there has been opposition on the part of the I. A. as an international to the enactment of license laws, though many local unions have worked for and secured them.

The author of this book is on record as favoring the enactment of license laws, even though there be a fee attached thereto, although any fee other than one sufficient to cover the actual cost of the operation of the law is unquestionably wrong from any and every viewpoint. Society has the right to protect itself against the incompetent, but it has not the right to charge a man for the privilege of working at his chosen calling, and any fee over and above that necessary to pay the cost of operating the law would amount to exactly that.

The benefit of the license law is made evident in the fact that, at least to some extent, it operates to curtail the supply of incompetent projectionists.

It is, however, foolish to suppose that the mere existence of a license law will create competent projectionists. That can only be done by the proper administration of a well framed law, and the principal part of the administration is the holding of an examination which can only be passed by men who really understand both the practical and technical end of their profession.

Given the best law in the world, and an examining board from which licenses can be bought, or an examining board which plays favorites in an examination, or an examining board the members of which themselves lack the knowledge necessary to conduct a really competent examination, and the law is very largely made of no effect. On the other hand, given a proper law and an honest, competent examining board, great good will be accomplished both to the profession and to the industry as a whole, or, perhaps we might better say, to all concerned.

A SERIOUS ERROR.—One fundamental error found in most examinations is that the examiners seem to recognize only one danger to the public, and that is the danger of fire. The truth of the matter is that with modern projection room construction, and the fact that the public now very generally understands that it is in no real danger from a projection room fire, the fire danger lacks considerable of being of as much importance as is danger of injury to the eye-sight through eye-strain.

There is no more eye-strain in a properly projected moving picture, projected under proper conditions of auditorium lighting, than there is in reading this printed page in good light, but if the projection be unintelligently done, or if the auditorium lighting be wrong, there may be very serious eye-strain. It is therefore of very great importance that the examination include a really competent investigation of the knowledge of the projectionist as applies to the optics of projection.

It is quite true that fire danger was what first brought about the licensing of projectionists. It is also quite true that at that time danger to the audience from film fire was a real one because projection rooms were not then thoroughly fireproof. Also in that day newspapers went to great lengths in what seemed an endeavor to impress the public the danger to audiences from film-fire, which action on their part was very largely responsible for the causing of wild panic the instant a projection room fire became visible to the audience.

Improvement in both projection machinery and projection room construction and **the education of the public to the fact that there is little or no danger to them from a projection room fire** has changed all this, whereas increased brilliancy of projected light and other things have made the item of eye-strain, set up by improper procedure, of very greatly increased importance. **It is therefore rather absurd to hold an examination covering only electrics when optics is in many ways now the more important.**

The licensing power ought also to be deeply interested in the knowledge of the projectionist as to auditorium lighting, since not only may the value of what the audience pays its money to see be greatly lessened by improper lighting of the auditorium, but mistakes in lighting of the auditorium while the picture is on may operate to set up literally tremendous eye-strain to the audience, or to portions of the same.

Only the competent man will be able to keep the projector in such adjustment and in such repair that there will be a minimum of movement in the picture on the screen. Also, only the competent projectionist who is thoroughly conversant with the optics of projection in all that subject entails, can so adjust and trim his revolving shutter that it will meet the local condition, and thus enable the projection of pictures at proper speed without flicker. Also, only the competent projectionist can so select and adjust the optical system of the projector that there will be no unnecessary waste in electric energy, and wasted electric energy not only means unnecessarily excessive bills for current, but also a waste of the diminishing fuel resources of the country. True, this latter might amount to very little in one theatre, but if there be a waste of even so little as 500 watts (it will probably average considerably more than this) in each theatre, when we multiply 500 watts by the 16,000 theatres in the country, the aggregate of waste becomes 8,000,000 watts of energy, chargeable directly to incompetency, and 8,000,000 watts or 8,000 kilowatts is no small matter when we reduce it to terms of coal, or when we add its costs to the overhead of the industry. It is close to 2,000 horsepower, and at 8 cents per kilowatt hour would amount to $3,200 per day, if all theatres ran an average of five hours a day, or a total of $1,168,000 a year added to the overhead of the industry.

NEWSPAPERS AND FIRE DANGER.—Let us for a moment direct attention to the responsibility resting upon the newspaper editors of this country, who permit the publication of ridiculous stories about fire danger as applies to the motion picture theatre.

Newspaper editors should inform their readers that in modern motion picture theatres the projection room is absolutely fireproof, and that a film fire therein entails absolutely no danger of any kind whatsoever to the audience, except possibly the unpleasant experience of breathing a little smoke, always provided the audience leaves the theatre decently and in order. In modern motion picture theatres absolutely the only danger to the audiences from film fires is summed up in one word—"PANIC."

We make the broad assertion that newspaper editors themselves are very largely responsible for all injury and death resulting from motion picture theatre fire panics through their failure to inform their readers of the facts in the case.

We do not wish to be understood as intimating that the projectionist should not be thoroughly examined as to his ability in electrics and along the lines of fire hazard. Aside from danger to the audience, a projectionist is placed in charge of valuable property within the projection room, which may be either seriously damaged or even entirely destroyed by fire. It is, therefore, right and proper that he be examined along these lines, but that should be only a part of the examination.

In connection with these things it must, of course, be admitted that the projectionist who is thoroughly competent so far as technical knowledge goes, may be in fact thoroughly incompetent because he is too shiftless or lazy to apply his knowledge. The fact remains, however, that the man who is competent in technical knowledge can be compelled to do his work right, whereas the man who does not possess technical knowledge cannot be compelled to do his work right because he does not know how.

INCREASES EFFICIENCY.—The licensing of projectionists, even if the examination is not what it ought to be, tends to increase efficiency, because knowing they must pass an examination the candidates will do at least some studying, and the knowledge thus acquired they would not in all human probability otherwise possess.

The exhibitor, and the theatre manager who is a real manager, will not oppose anything tending to increase the efficiency of projectionists, because it is upon that efficiency he must depend, not only for results on the screen, but also for the securing of those results without excessive cost.

The author is heartily, thoroughly and completely in accord with the licensing and examination of projectionists. He suggests, however, that it is essential to good results that the examining board be either wholly or partly composed of men who have at least a fair working knowledge of practical projection.

The fact that a man occupies a position as head of a city department or state department is absolutely no proof that he is a competent examiner for moving picture projectionists, any more than he would necessarily be a competent examiner for locomotive engineers or sea captains; also, the fact that a man is a competent electrician does not qualify him to examine projectionists, except in so far as their knowledge of electricity is concerned, which latter is but a relatively small part of the knowledge necessary to competency

COMPOSITION OF EXAMINING BOARD.—It is hard to say just what the make-up of an examining board should be. The following is perhaps as near the composition of a competent examining board as it would be possible, everything considered, to get: (a) One thoroughly competent, practical electrician; (b) the head of building or fire inspection department; (c) one man who is thoroughly acquainted with practical projection room practice—in other words, a competent projectionist.

THE EXAMINATION.—The examination of projectionists should seek to determine: (a) Their knowledge of electrical action in general; (b) their knowledge of electrical action as applies to the ordinary multiple arc and three-wire system—particularly the latter; (c) ability to measure wires, to calculate their ampere capacity and their general understanding of what various things happen, or may happen, when a wire is overloaded, and why they happen; (d) their knowledge of what types of installation (wiring, etc.) are permitted for use under various conditions met with in the theatre; (e) extent of their knowledge of the principles involved in transformers, and of the construction, connecting and operation of low voltage transformers or economizers such as are used in projection rooms; their knowledge of motors and motor generators, particularly as applies to the care of the commutator, brush tension, methods of fitting the brushes to the commutator and testing for possible electrical faults; (g) knowledge of the principles involved in, and the practical operation of the mercury arc rectifier, if they are used in the territory; (h) knowledge of principles involved in fusing, including knowledge of all places where fuses are required, and what types of fuses it is permissible to use in a theatre; (i) knowledge of rheostat resistance and its application to the projection circuit; (j) Knowledge necessary to determine whether or not wires are large enough to carry any given current, considering length of circuit; (k) knowledge of the various points in projection room construction and equipment, including proper methods of port fire shutter suspension, fusing port fire shutter suspension system, particularly as applies to location of fuses, and method of manual operation of same; (l) knowledge of the projection mechanism and of the light source; (m) knowledge of film, including how to make a proper, straight, smooth splice, the effect of worn sprocket teeth on the film and on the projected picture; the effect of worn aperture plate tracks on screen results; (n) knowledge of optical principles involved in the revolving shutter of the projector, including how to make a shutter fit local conditions as nearly as it can be made to do so; (o) knowledge of proper storage of films in the projection room; (p) knowledge of proper projection room lighting and its effect on projection; (q) knowledge of screen surfaces and their effect in auditoriums of different dimensions; (r) knowledge of proper picture size under various conditions, the effect of seats being placed too close to the screen; (s) knowledge of how to measure focal length of lenses; (t) knowledge of proper selection of and adjustment of the various elements of the projector optical system, and such other things as may occur to the examiners, not overlooking the cause of damage to film in re-winding and how to minimize it, and the various effects of overspeeding projection.

COMPETENT EXAMINERS.—Up to date what is perhaps the worst trouble in the whole licensing proposition is that very few examiners are themselves equipped with the knowledge necessary to conduct a really competent examination. Also, few examining boards are supplied with the equipment necessary to the conduct of a competent examination. We might add that **the issuance of licenses except to men who have successfully passed a really competent examination savors of dishonesty to the public; moreover, it savors of highway robbery to compel a projectionist to pay a fee for a license which is issued as the result of an examination having little or no practical value.**

ROUGH DRAFT OF LICENSE LAW.—It would be impractical to include a model law in this book, because of the difficulty in framing one which would, in all its details, be applicable to varying local conditions. Fundamentally such a law should be the same in any locality, and the fundamental principles involved I shall set forth, leaving the necessary details to be worked out to fit individual local needs.

(1) Designate places in which it shall be illegal to display motion picture films until the projection apparatus and the projection room have been approved and duly licensed. Name the licensing power and give it authority to make necessary rules and regulations and to enforce them.

(2) Provide for an examining board, for the necessary equipment and for the examination. Specify briefly the qualifications necessary to obtain such license, which must include a competent knowledge of projection optics, the pro-

jector optical system, electrics and electric appliances as applied to projection work, fire hazard and local laws which apply to projection work. Require that the applicant for license shall have a certain amount of experience, either as a projectionist or projectionist's assistant to be eligible for examination. Establish a minimum age of a projectionist, which in no event should be less than nineteen years. As a matter of fact, twenty-one should be the minimum.

(3) Provide for the licensing of persons to act as assistant to projectionist, and designate what work they may do in the projection room, and what they shall not do, one item of which is that they must not project pictures until a stated period of not less than one-half on the total time of apprenticeship has passed, and then only when a licensed projectionist is present in the room; minimum age to be the requirement for a projectionist less the time of apprenticeship required by law.

(4) Provide for fees to be paid for the licensing of projectionist and assistant; also for annual renewal of the two last mentioned licenses, and fee for the same. These fees should be only sufficient to bear actual cost of operation of the law.

(5) Provide penalties for violation of any provision of law, or any rule or regulation made by the licensing authority.

(6) Provide that license MAY (not shall) be renewed at expiration without re-examination, provided application be made within a stated period, not exceeding thirty days, after such expiration.

In addition to these general provisions we would suggest that the law governing projection rooms should make provision for (a) their thorough ventilation; (b) **a vent flue sufficiently large to carry away all fumes and smoke in case of film fire, same to contain an electric exhaust fan of ample dimensions;** (c) a fire shutter fusible link system along the lines suggested on Page 314, (d) forbid placing conduit on the floor surface; (e) that the projection room construction be such that its walls will be thoroughly fireproof, and that either brick, hollow tile, or concrete be required where its use is practical; (f) that the projection room feed wires be large enough to carry the combined current capacity of all apparatus in the projection room, regardless of whether it is ever all used at one time or not; (g) that the wiring be so done that the projectionist will, in case of need, be able instantly to switch on at least a portion of the auditorium lights; (h) that a metal receptacle for hot carbon butts be required; (i) that all film rewinding and repairing be done either inside the projection room or in a fireproof room immediately adjoining and connecting thereto; (j) that a proper fireproof metal receptacle, containing a separate fireproof compartment for each film, be required for film storage, and that it be required that all film not in actual use, in process of repair, or rewinding be at all times kept in their receptacle; (k) that metal lining of projection rooms be forbidden; (l) that the projectors be thoroughly grounded to the metal framework of the projection room, if such there be; (m) that the keeping of oils, alcohol or highly inflammable substances in quantities of more than two ounces each be forbidden; (n) that no exposed inflammable material be allowed inside the projection room except a workbench of two-inch hardwood lumber, and such hardwood shelving as may be required, all wood for such purposes to have first been soaked for forty-eight hours in a fireproofing solution, see page 249; (o) that observation ports shall be not less than sixteen (16) inches wide, square or rectangular in form, and of such height as will provide a good view of the screen by a man of minimum and maximum height when seated or standing in working position beside the projector. See page 307.

Electric Meters

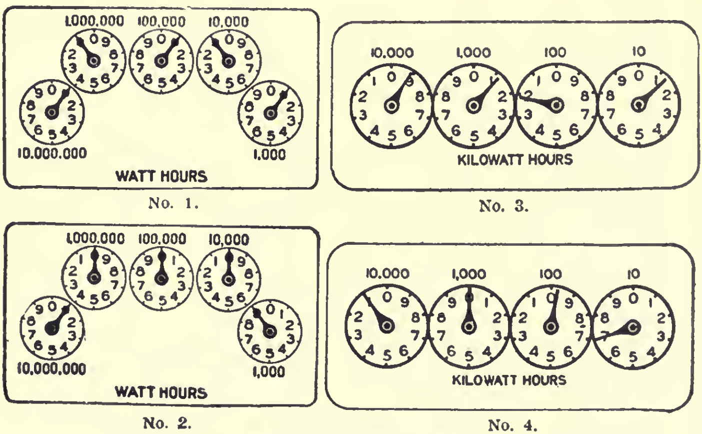
THE watt hour meter is the instrument now in general use for measuring the electric power consumed. The measurement is in watt hours, the meaning of which is that a certain number of watts have been used for a certain given number of hours, the use of one watt for one hour being the unit of measurement. The principle of operation of the electric meter is as follows:

The dial which records the consumption of the power is operated by a specially constructed, very small motor, placed in series with the current consuming apparatus. The motor is so constructed that if it were operated at a pressure of one volt for a period of one hour, during all of which time one ampere of current flowed, it would record one watt, or, in other words. one watt hour. This means that if, for instance, the motor be run for one hour under a pressure of 110 volts, with 10 amperes of current flowing, it would move the dial hand just far enough during that hour to record $110 \times 10 = 1{,}100$ watt hours, or 1.1 kilowatt hours, or if the pressure be 110 volts and the amperage 100, then during the same time the motor would move the dial hands far enough to record $110 \times 100 = 11{,}000$ watt hours, or 11 kilowatt hours. This roughly describes the principle of operation upon which the electric meter is based, and in a work of this kind that is all that could be expected, because to give you a thorough detailed understanding of meters would consume a great deal of space, without commensurate benefit.

TESTING METER.—If it is suspected the meter is wrong the instrument may be roughly tested in several ways, one of which would be to connect an ammeter into the lines and a volt meter across the lines near the meter. Read the meter and then burn a number of lamps for a period of exactly one hour, during which time the meter must record exactly the wattage obtained by multiplying the reading of the ammeter by the reading of the volt meter, both of which should first be tested to make sure that they are correct. This is not intended as a conclusive test, but if after making such a test there is a discrepancy between the meter and the wattage indicated by the volt meter and ammeter, then you should insist upon the power company making a regular test of the meter. In making such a test, however, it is imperative that the voltage and the amperage remain absolutely constant during the entire period of the test.

READING THE METER.—An electric meter is read precisely the same as is the gas meter. First carefully note the unit at which the dials are read. On all meters used by the Edisoń Company the figures above or below indicate the value of one complete revolution of the pointer, hence one division indicates 1/10 of the value of the complete revolution of the dial hand. Carefully note the direction of rotation of the dial hand, as indicated by the figures, the pointers moving, of course, from 0 to 1, 2, 3, 4, etc. Each dial will read in an opposite direction to its neighbor.

Counting from right to left on a five-dial register the pointers of the first, third and fifth dials of a watt hour meter rotate in the direction of the hands of a watch, or to the right, while the hands of the second and fourth move in the opposite direction, or counter-clockwise. The same holds true of the four-dial register. The hands of the first and third dials move to the right and the second and fourth to the left. The dials must always be read from right to left, and the figures set down as read, remembering that **until**



Facsimiles of Meter Dials.

Figure 366.

the hand has reached a division that division must not be counted. For instance: In No. 3, Fig. 366, the right-hand dial has passed 1, but has not yet reached 2, therefore it reads 1. Likewise the second or 100 dial hand has passed 2, but has not reached 3, hence it reads 2. Taking No. 1, Fig. 366, for example, it reads as follows: A complete revolution of the right-hand dial would be 1,000 watt hours, but the pointer has just reached the figure 1, which, being 1/10 of 1,000 is 100. We therefore put down 100. The next dial stands at 1, which, since one division is 1/10 of the total of 10,000, equals 1,000. Therefore we set down 1 at the left of the 100, and have 1,100. The next dial also stands at 1, which being 1/10 of 100,000, is 10,000, so we set down another 1 at the left of 1,100, and have as a total 11,100. The next dial stands at 1, so we set down another 1 to the left, and as a result have 111,100. The last dial stands at 1, which calls for still another 1 at the left, and we have a final reading of 1,111,100 watt-hours. No. 3, Fig. 366, reads in k. w. hours. It is read the same as is No. 1. The right-hand dial registers up to 10 k. w. h. The pointer is passed 1, but has not yet reached 2, therefore we put down 1, that being 1/10 of the total of 10. The pointer of the next dial has passed the 2, but has not yet reached 3, therefore we put down a 2 to the left of 1. The pointer of the third dial reads 1, and that of the fourth 9, therefore we have a total reading of 9,121 k. w. h. In No. 2, Fig. 366, the pointer stands at 9, which would mean 900 watts. The next three dials stand at 0, therefore we precede 900 with three 000's, thus 000,900. The pointer of the last, or 10,000,000 dial, stands at 1, so that the reading would be 1,000,900 watt-hours. The reading of No. 4 would be 1,097 kilowatt hours.

CAUTION.—Some meters read as per their dial indication. Other meters are not direct reading, but require that the actual reading shown by the dials be multiplied by a constant in order to obtain the correct reading. This is for the purpose of keeping meters of various capacities at fairly uniform size. If the constant were not used meters of larger capacity would be of greater dimensions than those of small capacity. If the register face bears the words "multiply by 3," or any other number, then you must multiply the actual reading as indicated by the various dial faces accordingly.

The theatre manager or the projectionist should always read the meter when the company man reads it, and make a

record of the reading in a book kept for that purpose. This is not only a goodly precaution, but it enables the computation of the current consumption at any time it may be desired. For instance, when the man reads the meter, it registers 1,000 kilowatt hours, that being on the first of the month. On the 10th of the month you take another reading, and the difference between the two will indicate the energy consumed during that period.

KNOWLEDGE IS POWER.

Bell Wiring

THE electric bell and annunciator play quite an important part in a theatre. The installation of a single bell is illustrated in Fig. 367. After installing the bell and the push-button in the location desired one wire is run directely from one side of the push-button to the bell. Another wire is run from the other side of the bell to one

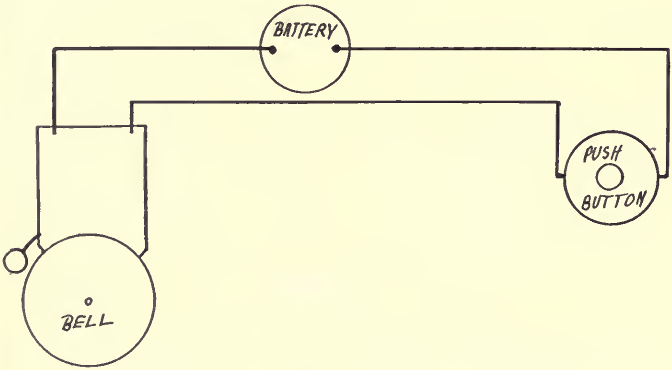


Figure 367.

side (either one, it makes no difference) of the battery, and another wire is run from the other side of the battery to the other side of the push-button. This completes the installation. For a single bell one battery alone or two batteries in series may be used. By series I mean two batteries, with the carbon of one battery connected to the zinc of the other battery by means of a short wire, as at A, Fig. 369. The effect of two batteries connected thus is to cause the bell to ring louder.

The ordinary practice in moving picture theatres is to use either bells, buzzers, or small, low candle-power lamps for signaling to the projection room, piano player and the manager. Of the three, the lamp system, if properly installed, is the best, with the buzzer as second. The bell should never be used. A buzzer is merely an electric bell without the bell part.

What is known commercially as the dry battery is best for theatre work. Wet batteries are very effective, and very cheap in operation, but they are liable to freze in winter and thus cause a lot of trouble. The dry battery is cheap and effective.

For wiring bells No. 18 ordinary cotton covered bell wire is

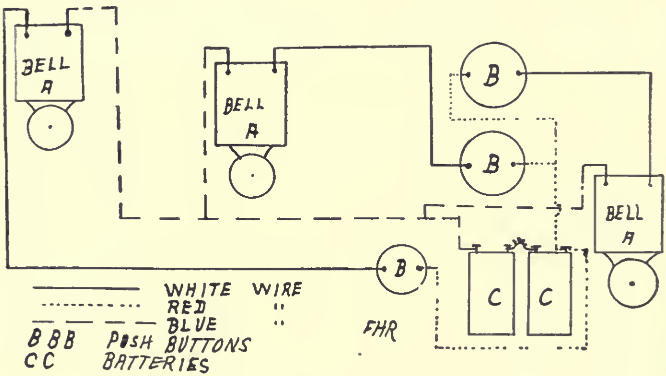


Figure 368.

plenty good enough, unless the circuit be a very long one, in which case No. 16 might be used. This holds good, except in very wet places, where it is better to use rubber covered wires, supported upon porcelain insulators.

In putting up bell wires they may be gathered together in a cable and held to the wall with a wooden cleat. They may be run singly around picture molding, being held thereto by small iron staples, but where this is done a staple should never be driven over two wires, since it is likely to cut through the insulation and short-circuit the bell, the battery or both. Never drive a staple over two wires. Hold each wire with its own staples. A short circuit may cause your bell to ring all the time or not ring at all, according to its location. If on the two wires leading to the push-button the bell will ring continuously until the battery is worn out. If on the wire running from bell to battery and the wire running from button to bell the bell will not ring at all. Joints in the wire should be made in the usual way (see wire splices, Page 123, and should be soldered and wrapped with insulating tape. Never run your wires in a slipshod manner. Always do a job in a workmanlike way. Stretch the wires tightly and run them as they should be run. Loose, sagging wires advertise the poor workman.

A, Fig. 369, shows series connection of batteries, which has the effect of raising the pressure approximately one volt for each battery added. B shows multiple connection, which increases amperage, but not the voltage, and C a series-multiple connection which increases both volts and amperes.

A very common practice in theatres is to use what is known as the three-wire system of bell wiring. This system is the most economical in that it requires a comparatively small amount of wire for the installation of several bells. By its use any number of bells may be run with one battery, and each bell has its own individual push-button. No push-

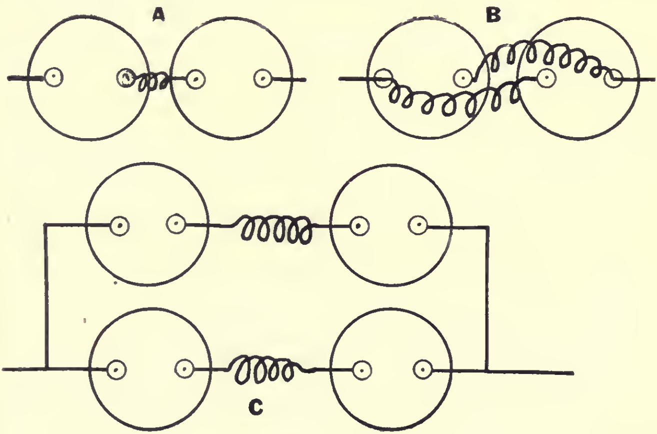


Figure 369.

button will ring any bell but its own. Put up the bells, buzzers, or lights, and the push-button wherever you wish them to be. Use two batteries, connecting the carbon of one to the zinc of the other. Get bell wire of three different colors. The installation is illustrated in Fig. 368, in which A-A-A are bells, B-B-B push-buttons, and C a two-cell dry battery.

The reason for three colors is to avoid mistakes and confusion and to be able to find any particular wire anywhere afterward, without tracing it clear from the battery or bell. The use of three colors of wire simplifies matters very greatly. Suppose you get red, blue and white. You take one color, say, the blue, and run it from one (either) binding post of the battery to one (either) binding post of each bell. You may run separate wires from the battery binding post to each bell or run one wire reaching all bells or you may

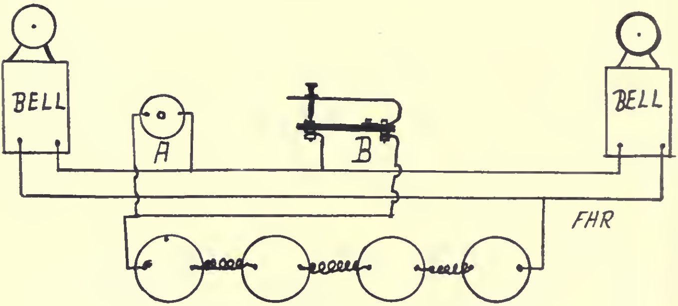


Figure 370.

branch off to a bell at any point. Next take another color (red, for instance), and run from the other battery binding post to one (either) side of each push-button. You now have one side of the battery connected to one side of each bell and the other side of the battery connectd to one side of each push-button. You next, with the remaining color (white) wire, connect the remaining side of each push-button with the remaining side of the bell it is to ring, and the job is done. The blue wire (blue in this case) is called the common bell wire, the red wire is called the push-button wire and the whites are called the individual wires. It is these latter wires which determine which bell a button will

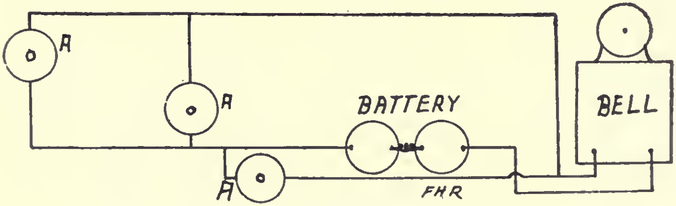


Figure 371.

ring and you may cause a button to ring a different bell by simply changing the individual wire to that bell. Fig. 368 shows a plan of this system.

An additional bell easily may be installed at any time as follows: Test the bell and install it and its push-button wherever you want them to be. Now with a piece of the first color wire connect one binding post of the bell with the first color wire already in use wherever you can find it. With a piece of second color wire connect one side of the push-button with a second color wire wherever you can find one. Understand you can just tap on to these wires at any point you can locate one of proper color. Now connect the remaining side of the button with the remaining side of the bell with third color wire and the job is done. The rules governing this system of wiring are as follows: One side of

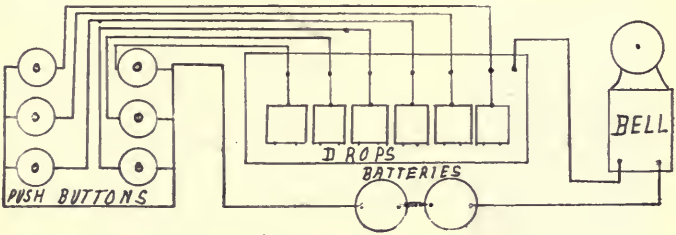


Figure 372.

the battery must be connected with one side of each bell by first color wire. The other side of the battery must be connected to one side of each push-button with second color wire and the remaining side of each button must be connected with the remaining side of the bell it is to ring with third color wire.

The various battery combinations are illustrated in Fig 369. A increases the voltage without affecting the amperage. B increases the amperage without affecting voltage. C increases amperage and voltage. A is series, B multiple and C is a multiple of series.

In Fig. 370 we see two fire bells, one located, let us suppose, in the manager's office, and the other on the stage, or at any other suitable point. We also see an ordinary push-button at A, and a form of contact more suitable to such work at B, either of which will ring both bells. As many of these may be attached as desired, locating them at any point in the house. Attach one side of the button to upper wire and the other side to the battery wire, as shown. In the illustration we see four batteries connected in series. This being a fire alarm system, it is desired that the bell or buzzers ring very loudly, hence several batteries are connected in series. Employees should be made to understand that it will mean instant dismissal to ring these bells, except in case of actual necessity. The system can be arranged for any number of bells, from one to a dozen, and there can be as many push-buttons as desired.

Fig. 371 illustrates the method of connecting a bell so that it may be rung by more than one button. By this plan as many buttons may be installed as desired, any one of which

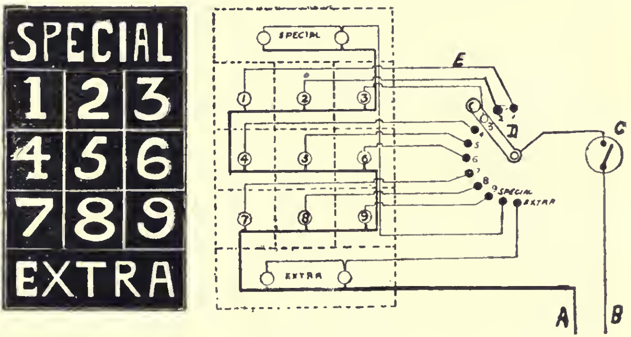


Figure 373.

will ring the bell, provided the wire from push-button to battery wire be not connected between battery and bell. A-A-A are push-buttons.

In Fig. 372 we see the method of wiring an ordinary annunciator. The plan is too plainly shown to require explanation. The buttons may, of course, be located anywhere in the building, and ordinarily are widely separated.

ELECTRIC PROGRAMME BOARD.—Fig. 373 is the wiring diagram of an electric programme board. I think the action will be plain when you trace through the contacts in Fig. 373.

Wire A, we may call the permanent connection. As you will observe, it connects directly to one side of all the lamps. Wire B connects through switch C and movable arm D to the various contacts 1, 2, 3, 4, etc. Now suppose we place arm D on contact 1. You will observe that the current will flow through wire E, through lamp 1, and thence back through the other wire, and that no other lamp will be affected. If we move the arm to contact 6, then only lamp 6 will be lighted. Such a board is simple, entirely practical, and, as we have said, is the best plan we have seen. It is also quite possible to substitute single pole, single throw knife switches for contacts 1, 2, 3, 4, etc., connecting wire B to one side of all these switches. The switches or the contacts should be located at the most convenient point, either on the stage, by the side of the musician or in the projection room. The transparency can be so made that only the figure or name actually illuminated will be visible. This may be done by covering the whole front of the board with ground glass, on which are the figures, or names blocked out in

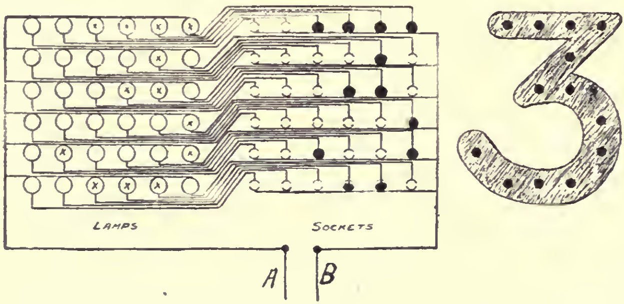


Figure 374.

black, as shown in the illustration, each lamp, however, being contained in a light tight compartment of its own. Different colors may be obtained, if desired, by covering the various characters with light shades of gelatine or using colored globes.

In practice, we would by all means advise a double-pole single throw switch at AB, rather than the single-pole knife switch at C. In fact switch C would be a violation of Underwriters' rules.

In Fig. 374 a battery of 36 lamps is arranged in the form of a square, with 6 lamps either way. One wire (wire A, in the sketch) is connected directly to one side of each lamp. A board is now made, containing 36 sockets, arranged in a square, with 6 sockets each way, the same as are the lamps.

This board may be placed in any convenient location, either near the lamps or removed at a distance from them, as may be most convenient; but in any event the other side of each one of the lamp sockets must be connected to one side of each socket as shown. We now connect the other side of each one of these sockets to wire B, as shown in the illustration, installing a double-pole, single-throw switch, at any convenient point in wires A, B. Both sides of the socket are now alive, one directly from wire B and the other by way of the lamps through wire A. It will be readily seen that if an ordinary plug fuse be screwed into any one socket the lamp connected to that socket by cross wire will immediately be lighted and will burn until the plug is removed. Suppose we wish to form a figure 3. It would be only necessary to insert the plugs in the sockets indicated in order to outline the figure 3 on the board, wherever it might be placed. In using such a plug board it is advisable to have a pattern of the various figures and letters it is desired to use. Patterns may be made of cardboard.

Where printed programmes are used it is quite possible to install such a board at the side of the stage, with the plug board and the switch controlling the supply wires located in the projection room, within convenient reach of the projectionist. He can then plug in any desired number and illuminate the same by merely throwing in the switch, i. e.: Supposing he is running reel 2, the next being, of course, reel 3, which is described on the programme under that number. He prepares Fig. 3 by placing the plugs in position in the board, and as reel 2 is finished he throws in the switch, illuminating figure 3, thus allowing the audience to look at the programme while the next reel is being threaded or during the interval between the two reels. Where only one number is to be used the board can be made very small, and it is not necessary to use more than two or three c. p. lamps, these being of the proper voltage, of course. Such a board can be used to decided advantage in many ways. The lamps, if used within the auditorium, should be frosted or else heavily colored. It is possible to so connect the various figures through batteries of switches that the plug arrangement is unnecessary. This is more costly, and the plug serves every purpose. It is quite possible to substitute single-pole, single-throw switches, or ordinary snap switches in place of the plugs. The arrangement shown in Fig. 374 is much the best for programme announcements.

COLORING INCANDESCENT LAMPS.—Projectionists or theatre managers who may desire to color incandescent globes may procure ready-made coloring liquid from any supply dealer. These liquids come in red, green, blue and amber.

Colored incandescent globes will require re-dipping occasionally, because the heat of the globes gradually deteriorates the color. Color is applied by the simple process of dipping the incandescent globe into the liquid, afterward allowing it to dry.

The Eastman Kodak Company recommends the following formula as calculated to produce a very pleasing amber color, with the remark that other dye materials may be used when some other color is desired:

4½ ounces Sandarac (Powdered).

½ ounce Venice Turpentine.

58 grains Metanil Yellow No. 1955. (National Aniline Co., Buffalo, N. Y.).

½ fluid ounce Lavender Oil (Garden).

26½ fluid ounces Denatured Alcohol.

Projectionists' Library

IT is not only desirable, but necessary that those projectionists who wish to succeed have available such books for study and reference as deal with those various things it is necessary to know. We have given considerable thought to the matter of what books are really necessary. To be of use a book must be written in such a way that the purchaser can understand it, and but comparatively few projectionists are able to use or understand technical language, or any other than very simple diagrammatic drawings. To most projectionists a performance curve diagram is just as intelligible as so much Greek. It is, therefore, all but useless to recommend to him books which do not explain things in very plain, simple language, and use simple, understandable drawings.

The books we have selected are among the good ones; they cover the entire ground with at least very fair degree of completeness.

We recommend to you the following:

Optic Projection, by Simon Henry and Henry Phelps Gage, 730 pages, well bound in cloth; price, $5.00.

The Hawkins Electrical Guides, ten volumes, with a total of 3,366 pages, bound in limp imitation leather; plain, understandable and complete.

The Electric Motor, by Elmer E. Burns.

Moving Pictures; How They Are Made and Worked. By Frederick A. Talbot; of no especial direct benefit to the projectionist in his work, but will be of interest to him, especially in those chapters where it is explained how the various "tricks" in photography are performed. 340 pages.

The various proceedings of the Society of Motion Picture Engineers are recommended. They may be purchased from the secretary of the society.

The Projection Department of Moving Picture World, which has been the leader in matters projectional for many years.

As to projection itself, we know of no book, other than this one, which we could conscientiously recommend. We know of no other work which covers the ground even fairly well. We do know of some books on the subject of projection which are very much worse than useless, because they are wrong and misleading in many things. We, therefore, caution you to be very careful when buying books dealing with the projection of motion pictures.

THIS BOOK IS TO STUDY—NOT TO LET LIE ON A SHELF.

Decimal Equivalents

The following complete table of Decimal Equivalents from 1/64 to 63/64 of an inch, by sixty-fourth steps, was compiled

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

1947 Broadway New York City

Figure 375.

by the Lake Sales Company, New York City. We present it believing it will be of considerable convenience to users of this book. We are indebted to the Lake Sales Company for permission to use it.

CENTIGRADE AND FAHRENHEIT SCALES

Centigrade	Fahrenheit	Centigrade	Fahrenheit
0	32	50	122
5	41	55	131
10	50	60	140
15	59	65	149
20	68	70	158
25	77	75	167
30	86	80	176
35	95	85	185
38	100.4	90	194
40	104	95	203
42	107.6	100	212
45	113	..	..

MELTING POINT OF MATERIALS

	Fahrenheit		Fahrenheit
Mercury	—39	Bronze	1,692
Tin	442	Silver	1,873
Bismuth	507	Copper	1,996
Lead	617	Gold	2,016
Zinc	773	Cast Iron, Gray	2,786
Antimony	1,150	Steel	2,372 to 2,552
Aluminum	1,157		

TABLE OF REFLECTION POWERS BY DIFFERENT SURFACES

This table should be of value to those selecting theatre interior decorations. The percentages indicate the proportion of the total light falling upon the various surfaces which is reflected.

Material	Per cent.	Material	Per cent.
Polished silver	92 to 93	Yellow cardboard	30
Mirror silvered on back	82 to 88	Light blue cardboard	25
White blotting paper	82	Brown cardboard	20
White cartridge paper	80	Yellow painted wall, dirty	20
Polished brass	70 to 75	Emerald green paper	18
Mirror backed with Amalgam	70	Dark brown paper	13
Ordinary foolscap paper	70	Vermilion paper	12
Chrome-yellow paper	62	Bluish green paper	12
Orange paper	50	Cobalt blue paper	12
Yellow wall paper	40	Black paper	5
Yellow-painted wall	40	Ultramarine blue paper	3.5
Light pink paper	36	Black velvet	.4

FRACTIONS.—In the making of calculations it is often necessary to add, subtract, multiply or divide fractions, and not every one can remember how to do it. We, therefore, give you the rules.

ADDITION.—To add two fractions it is first necessary that each one represent the same value as to parts· You cannot add 4/5 and 1/3, but you could very easily add 12/15 and 5/15, and 4/5 and 12/15 and 5/15 and 1/3 have identically the same value. Before addition we, therefore, must give both fractions the same part value, which in arithmetic is called reducing them to a common denominator. Any two fractions may be reduced to a common demoniator by multiplying both factors of each fraction by the denominator of the other fraction, thus in adding 2/3 and 1/9 we would have

$$\frac{2}{3} = \frac{2\times 9}{3\times 9} = \frac{18}{27} \text{ and } \frac{1}{9} = \frac{1\times 3}{9\times 3} = \frac{3}{27} \text{ and } \frac{18}{27} + \frac{3}{27} = \frac{21}{27}.$$

SUBTRACTION.—To subtract two fractions we proceed the same as for addition, but subtract the smaller numerator from the larger, thus: $2/3 - 1/9 = \frac{18}{27} - \frac{3}{27} = \frac{15}{27}$.

MULTIPLICATION.—To multiply a fraction by a whole number you may either multiply the numerator or divide the denominator by the whole number, as seems most expedient. The results will be the same, thus: $1/8 \times 4 = 4/8$ if we multiply the numerator, or 1/2 if we divide the denominator. The result is the same, because $4/8 = 1/2$.

To multiply a fraction by a fraction we multiply the numerators together for a new numerator and the denominators together for a new denominator, thus $\frac{3}{11} \times \frac{2}{7} = \frac{3\times 6}{11\times 7} = \frac{6}{77}$.

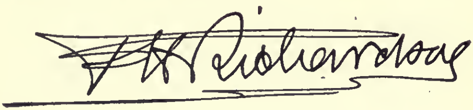
DIVISION—To divide a fraction by a whole number you may either divide the numerator or multiply the denominator by the whole number. The result will be the same in either case, insofar as has to do with value, thus: $\frac{8}{9} \div 4 = \frac{8\div 4}{9} = \frac{2}{9}$ or $\frac{8}{9\times 4} = \frac{8}{36}$, the value of 2/9 and 8/36 being the same.

To divide a fraction by a fraction you merely invert the divisor and then proceed as in multiplying one fraction by another, thus: $\frac{2}{3} \div \frac{5}{7} = \frac{2}{3} \times \frac{7}{5} = \frac{2\times 7}{3\times 5} = \frac{14}{15}$.

THIS book represents almost three years of hard work, as well as the knowledge and experience gained in all the years before. I hope and believe it will meet with your approval. If it does I shall feel thankful that my effort has not been in vain.

I ask that you look upon such errors as there may be with kindly tolerance, remembering that to create a work of this magnitude and character, covering a comparatively new field, without error, would be too much to expect, or even hope for.

It is with a feeling of literally tremendous relief, as in the laying down of a heavy, long-borne burden, that I dedicate this work to the memory of my friend of other days, James P. Chalmers, and sign



Questions and Answers

WE have adopted a plan of "questions and answers" covering the entire work. There are a total of 842 questions, grouped under headings, which we hope will be of much assistance to the student. The number following the question refers to the page or pages of text in which the answer can be found.

There is considerable duplication of questions. We found this to be inevitable, if we used the plan of grouping under headings, because quite often the same question would probably occur under three, four, or even more headings.

We for years have refused to accede to a wide-spread demand for the publication of "questions and answers," and such refusal has cost us many thousands of dollars. But the I. A. T. S. E. and M. P. M. O. International office has indorsed a book on motion picture projection which contains many pages of what amounts to examination questions, with the answers directly appended thereto, and inasmuch as the organization has officially approved of the proposition we see no reason for further refusing to publish questions and answers, but have tried to do it in the way which will be least objectionable.

Action of Light

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Motor Generators

Mercury Arc Rectifiers

The Transformer

Arc Controllers

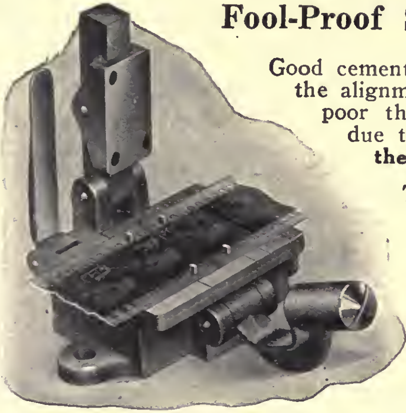
High Intensity Arc

The Spotlight

The Stereopticon

Madza Lamp Projection

Fool-Proof Splicing Machine



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